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ENVIRONMENTAL ASSESSMENT RELATED TO THE DECONTAMINATION AND DECOMMISSIONING OF THE ARGONNE NATIONAL LABORATORY CP-5 RESEARCH REACTOR

ARGONNE NATIONAL LABORATORY

June 1982

by the

Division of Environmental Impact Studies

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Argonne, Illinois

for the

U. S. DEPARTMENT OF ENERGY

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SUMMARY

1. The proposed action is the decontamination and decommissioning of the Argonne National Laboratory CP-5 research reactor. This will consist of the dismantling, removal, and transport of all radioactive materials, including the biological shield, to the low-level-waste burial site at Richland, Washington.

   The facility, located at Argonne National Laboratory in Du Page County, Illinois, about 35 km (22 mi) southwest of downtown Chicago, has been in safe-layup status (fuel and heavy-water moderator removed) since 28 September 1979. The enriched-uranium fuel and heavy-water moderator have been removed from the reactor and shipped to the Savannah River Plant at Aiken, SC. Decommissioning activities will be carried out by contractors under the direction of Argonne National Laboratory staff personnel. The cost will be about $12.1 million, if the activities begin in the first quarter of FY 1983 and are completed within 36 months.

2. Summary of environmental changes and impacts due to the action.

   a. <u>Nonradiological Impact</u>

   - There will be no adverse impact on land use; decommissioning of the facility will release about 1.2 ha (3 acres) of a previously restricted area for unrestricted use (Sec. 5.1.1), whereas radioactive-waste burial will occupy only an estimated 0.03 ha (0.07 acre).

   - No adverse water-quality or water-use impacts will occur as a consequence of decommissioning activities (Sec. 5.1.3).

   - Air quality in the vicinity of the facility will occasionally be degraded by dust raised during the demolition of small, reactor-related structures and the cleanup of the Building 330 waste-storage yard (Sec. 5.1.4).

   - Some of the biotic habitat, vegetation, and animal life of the 1.2-ha (3-acre) waste-storage yard will be disturbed or destroyed during decontamination of the yard. The impact will be negligible in terms of the local ecosystem (Sec. 5.1.5).

   - There will be minimal socioeconomic impact on the ANL area because, at most, only 50 additional workers will be onsite at any time during the decommissioning (Sec. 5.1.6).

b. Radiological Impact

- Radiological impacts on the population from nonaccidental releases of the radionuclides ^{3}H, ^{60}Co, ^{55}Fe, and ^{63}Ni will include a dose commitment possibly as high as 0.19 mrem to the lungs of an individual working onsite and located about 100 m (300 ft) to the northeast of the reactor building. The cumulative dose to the population within an 80-km (50-mi) radius is 8.33 person-rem (Sec. 5.2.1); this is about 10^{-5} of the annual natural-background dose for this area. The risks of significant radiological impacts on the population from accidents or natural catastrophies at the reactor site are extremely small (Sec. 5.3.1).

- A cumulative occupational dose of about 21 person-rem will be received by the work force of up to about 50 persons participating in the dismantling activities (Sec. 5.2.2).

- Population doses during the transportation of reactor scrap and wastes from dismantlement will be about 50% of the cumulative population dose within 80 km of the site (Sec. 5.2.3). For each decommissioning alternative the total population dose will be well below 10^{-5} of the average background dose.

- A cumulative occupational dose of about 24 person-rem could be received by the drivers of the transport trucks shipping the radioactive wastes to Richland, Washington.

3. Principal alternatives considered.

Alternative #1:

- The preferred alternative - removal of all radioactive materials and the biological shield.

Alternatives #2 and #3:

- Alternatives that do not involve removing the reactor vessel or the biological shield: mothballing and entombment techniques.

Alternative #4:

- Removal of all radioactive materials except for concrete in the biological shield.

Alternative #5:

- No action, leave in safe-layup status.

4. Project modifications to mitigate or prevent impacts.

a. Not involving radioactivity

Use of in-situ plastic tents with filtered exhaust will diminish dust concentration that originates from the breaking up of concrete structures. Careful dismantlement of parts containing asbestos will prevent dispersion of toxic fibers (Sec. 5.1.4).

b. Involving radioactivity

Numerous mitigative strategies to reduce occupational exposure have been described in detail in Appendix B and generally include good health-physics practices, shielding, remote handling, local ventilation, and protective clothing and devices. Sufficient mitigation will be used for each decommissioning activity to limit doses to prescribed safe levels (Secs. 5.2.1 and 5.2.2).

If unexpected harmful effects or evidence of serious environmental damage are observed during decommissioning operations, an analysis of the problem and a plan of action to eliminate or significantly reduce the harmful effects or damage will be developed.

Radiological impacts to the population from nonaccidental releases [illegible] as high as [illegible] rem to the lungs of an individual [illegible]

[illegible]

2. Population doses during the transportation of reactor scrap and wastes from decommissioning will be about 50% of the cumulative population dose from sources within 80 km of the site (Sec. 5.2.3). For each decommissioning alternative the total population dose will be well below [illegible] the average background dose.

3. A cumulative occupational dose of about 74 person-rem could be received by the drivers of the transport trucks shipping the radioactive wastes to Richland, Washington.

F. Principal alternatives considered.

Alternative 2C:

- The preferred alternative - removal of all radioactive materials and the biological shield.

Alternatives 2A and 2B:

- Alternatives that do not involve removing the reactor vessel or the biological shield: mothballing and entombment techniques.

Alternative 2D:

- Removal of all radioactive materials except for concrete in the biological shield.

Alternative 1:

- No action, leave as safe-layup status.

G. Project modifications to mitigate or prevent impacts.

a. Not involving radioactivity

Use of in-situ plastic tents with filtered exhaust will diminish dust contamination that originates from the breakup of concrete

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CP-5 RESEARCH REACTOR

1. INTRODUCTION

1.1 PURPOSE AND NEED FOR THE ACTION

This assessment is concerned with the proposed decontamination and decommissioning of the Argonne National Laboratory (ANL) Chicago Pile-Five (CP-5) research-reactor facility, and the removal from the ANL site of radioactive materials associated with its previous operation. It is intended that the proposed action be conducted within the framework of the National Environmental Policy Act of 1969 (NEPA), in accordance with all relevant Department of Energy (DOE) decontamination and decommissioning policies applicable to research devices that have ceased operation. The major goal of the proposed action is to release the structures currently allocated to CP-5 facilities for office and laboratory space, preferably with an "unrestricted use" classification.

In its present status, CP-5 represents a rather large and potentially hazardous source of radioactivity. It has outlived its usefulness for many types of research appropriate to its neutron intensities; in 1979, the research options remaining for CP-5 could not justify the continued expense of operation and the reactor was put in safe-layup status (fuel and heavy-water moderator were removed). As discussed later, CP-5 could be kept in its present condition indefinitely or could be modified with a range of decontamination options. However, no option short of the complete removal of the facility-related radioactivity from the ANL site would be compatible with DOE's policy of removing all potentially hazardous radioactive sources from unused facilities. Thus, it is the intent of ANL to completely remove all radioactive sources associated with CP-5 operation so that the facility can be fully decommissioned and the building grounds restored to the unrestricted-use criteria that will be defined after decommissioning is complete.

1.2 DESCRIPTION OF THE CP-5 FACILITY, ITS HISTORY, AND PRESENT STATUS

Chicago Pile-Five (CP-5) was the principal nuclear reactor used for the production of neutrons for scientific research at ANL from 1954 to 1979. The term "Chicago Pile" originated from the fact that the world's first nuclear reactor, built at The University of Chicago, was literally a pile of graphite blocks containing lumps of uranium and uranium oxide. This first pile was known as Chicago Pile-One, or CP-1. The term "pile" became generic and was applied to nuclear reactors whether or not they were piles of graphite. The fifth of the series was CP-5, which is contained in the Building 330 complex (Fig. 4).

CP-5 operated for 19 years of its 25-year life at a thermal power of five million watts (5 MW); it had originally operated at 1 MW. At this power level, the maximum neutron intensity in the core was nearly 10^{14} neutrons per square centimeter per second. During its lifetime, CP-5 generated more than 5.4×10^8 thermal kilowatthours. Because the purpose of the reactor was to produce neutrons for experimentation, the design did not make provision for the conversion of thermal power to electricity; thus, essentially all the power was dissipated to the atmosphere by mechanical-draft cooling towers.

CP-5 was a thermal reactor, in which neutrons from one generation of fissions were slowed by a heavy-water "moderator" before they produced another generation of fissions. Figure 7 is a cutaway drawing of the reactor as it existed during its operational period. The core consisted of 17 fuel assemblies, each of which contained three concentric aluminum-clad aluminum-uranium-alloy tubes. A new assembly contained about 170 grams of ^{235}U. The fuel assemblies were immersed in a tank of heavy water surrounded on the bottom and sides with (1) a layer of graphite, which acted as a neutron reflector; (2) layers of lead, which acted as a gamma shield; and (3) a biological shield of special, very dense concrete, which shielded experiments and experimenters from the radiation in the core.

Figure 7 also shows two of the four lever-arm shim-rod control blades and the regulating rod. The control elements contain cadmium, which is an excellent absorber of slow neutrons. Such elements were used to control the rate at which the fissions occurred. Gross power was controlled by the blades. Fine control was obtained by the automatically operated regulating rod.

Also shown are many horizontal and vertical penetrations (thimbles) through the lead and concrete shields. By means of the horizontal thimbles, neutron beams were obtained for use by experimental apparatus located outside the reactor. Figure 6 shows the placement of much of the apparatus currently in position. Experiments also could be conducted within the reactor by introducing apparatus into vertical thimbles. However, the vertical openings were used mostly to insert specimens to be made radioactive by neutron activation. Nearly 27,000 samples were accommodated during the 25-year operating life of the facility.

Funds for the design and construction of CP-5 ($2,175,000) were included in the 1951 budget of the Atomic Energy Commission. Construction of the reactor itself, exclusive of the building, cost $1,051,000. Criticality was achieved on 10 February 1954. The reactor began routine operation, at a power level of 1 MW, in March 1954. In 1959, modifications were made to permit operation at 5 MW. Routine operation began at that power level in 1960. In 1969-1970 the reactor was upgraded at a cost of $2,000,000, and then operated with a reliability of 0.968 (i.e. it met its operating schedule 96.8% of the time). Operation ended on 28 September 1979, when the reactor was shut down for decontamination and decommissioning.

Since shutdown, all fuel has been removed from the core and shipped to the DOE reprocessing facility at the Savannah River Plant. This final fuel removal, storage, and shipping was done using CP-5 operating procedures that have been standard for many years. The safety of the fuel, from the standpoint of accidental criticality, is addressed in ANL documents that have received DOE approval (ANL 1976, 1979b).

Most of the heavy water has been removed from the CP-5 system and is now stored at the DOE Savannah River Heavy Water Purification Facility.

1.3 PROPOSED SCHEDULE

Funds for the decommissioning of the CP-5 reactor have been requested to be authorized for FY 1983. The reactor will remain in safe layup until such funds are received. Major dismantlement activities are expected to begin in the first quarter following authorization and continue for 36 months. The tentative schedule of activities for dismantlement is given in Section 2.

2. DESCRIPTION AND ANALYSIS OF THE MAJOR ALTERNATIVES

At present, the CP-5 facility is in a safe-layup status, with the fuel and heavy-water moderator removed. It is unlikely that DOE will restart the facility. As stated in Section 1, the major purpose of the proposed action is to release the structures for office and laboratory use. Therefore, all the alternative actions considered in this assessment, except the no-action alternative, provide additional building space for future needs at ANL.

2.1 ALTERNATIVE #1 - THE PREFERRED ALTERNATIVE - REMOVAL OF ALL RADIOACTIVE MATERIALS AND THE BIOLOGICAL SHIELD

The removal of all radioactive materials and the concrete biological shield is the preferred approach proposed for the decontamination and decommissioning of the CP-5 facility. This approach has the following advantages:

- It would remove the liability for stored radioactive materials.
- The need for maintenance and for constant and continuing surveillance by health physics and security forces would be eliminated.
- It would free, for unrestricted use, a large, cylindrical high-bay structure (21 m or 70 ft in diameter and 11 m or 35 ft high) served by a polar crane with an 18,000-kg (20-ton) capacity.
- Delaying dismantlement would allow radioactivity of the reactor components to decrease. During that time there would probably be a loss of ANL personnel who are familiar and knowledgeable about the construction and operation of CP-5, and whose advice would have been of value during eventual dismantlement.

The major activities involved in dismantlement are listed in Table 2 and described in detail in Appendix B. The activity schedule for the proposed tasks is given in Table 3.

The spent-fuel cave/canal facility will not be decommissioned. The ability to top load radioactive parts to the cave (hot cell) for remote-control handling makes this facility unique and useful at ANL for examining or dismantling large fuel assemblies or other large radioactive components.

2.2 ALTERNATIVES THAT DO NOT INVOLVE REMOVING THE BIOLOGICAL SHIELD

In this section, alternatives that stop short of removing the concrete biological shield are discussed. The alternatives, in order of increasing completeness of removal of radioactivity, are mothballing, entombment, and removal of items inside the biological shield.

2.2.1 Alternative #2 - Mothballing

The reactor could be "mothballed," i.e. placed in protective storage. All persons could be protected from the radioactivity contained within the facility if constant security and health-physics monitoring were employed, but at substantial annual operating cost. Adequate radiation monitoring, environmental surveillance, and appropriate security procedures would have to be relied on to ensure that the health and safety of persons allowed in and around the facility would not be endangered.

In addition, the space within the containment building would not be available for unrestricted use and, thus, may not realize its best use.

The facility itself would not be protected from deterioration, except where containment of radioactivity would be involved. Mothballing of a reactor would involve the following major tasks for dismantlement: Nos. 1, 2, 4, 5, 10, and 11 cited in Table 2. The reactor vessel, its internals, and other radioactive components (primarily internally contaminated piping and vessels) would be kept in place. Controlled-access entrances would be secured.

This alternative for CP-5 would be considered for interim decommissioning if sufficient benefits would be realized by allowing the facility to stand for some period of time before final dismantlement. Possible benefits would be decreased potential for exposure to radiation during a deferred-decommissioning period and decreased amounts of materials requiring disposal as highly radioactive wastes, conditions that would occur if time for radioactive decay were to elapse before dismantling began. However, from computations given in Section 4.1 it is estimated that as much as 330,000 Ci of ^{60}Co, the dominant radioactive isotope, could be present in the reactor components. Because ^{60}Co has a half-life of about 5.3 years, it would take more than 20 years for the decay of radioactivity to substantially simplify the decommissioning of CP-5.

Furthermore, the mothballing alternative would have constant and continuing requirements for environmental monitoring and for surveillance by health-physics personnel and security forces.

For the above reasons, the mothballing alternative is, on balance, inferior to the preferred alternative of decommissioning described in Section 2.1. The environmental effects are compared in Section 5.

2.2.2 Alternative #3 - Entombment

Entombment involves the sealing of radioactive reactor internals within a structure integral with the biological shield after removing all fuel assemblies, radioactive fluids, wastes, piping, and other parts external to the structure for shipment offsite for disposal. The operations are essentially the same as for mothballing plus the sealing of all holes and other entrances to the reactor shielding and core. Inasmuch as the objective of entombment is to assure retention of the short-lived isotopes for 100 years or more, the concept involves encasement in concrete or steel walls. In fact, several experimental power reactors have been decommissioned by entombment with the expectation that the decay of radioactivity would reach normal background and permit unconditional removal methods after 100 years.

The alternative of entombment entails costs and benefits similar to those required for mothballing, e.g. health-physics and security surveillance, and the unavailability of valuable space for other uses. Although radioactivity would be contained within the entombed structure, ANL would remain liable for the safety of the facility.

For the above reasons, the entombment alternative is also, on balance, inferior to the preferred alternative of expeditious dismantlement.

2.2.3 Alternative #4 - Entombment of the Biological Shield After Removal of Contained Items

This alternative would require completion of all those operations needed for mothballing and would also require removal of all biological-shield internals (core tank, graphite, thermal shield, etc.) and all radioactive components of associated systems. However, the biological shield itself would be sealed to remain in place, thus leaving some radioactivity at the facility. The biological shield would provide adequate shielding to assure the protection of personnel. Minimal continuing surveillance would be required with this alternative. The decommissioning steps would be the same as for dismantlement (Table 2), except for task No. 9.

The main adverse impact of this alternative would be the continued liability of ANL/DOE for ultimate disposition of the remaining radioactivity. Except for the area occupied by the biological shield, the reactor floor of Building 330 could be put to other uses.

Because removal of the biological shield involves only about 10% of the cost of completely decommissioning the CP-5 facility, and because dismantlement would release the entire Building 330 complex for unrestricted use, the alternative of removal of items within the biological shield, and entombment of the biological shield, is considered, on balance, to be inferior to the preferred alternative described in Section 2.1. The environmental impacts of this alternative are also considered in Section 5.

2.3 ALTERNATIVE #5 - NO ACTION - MAINTAIN FACILITY IN ITS PRESENT STATUS

It is possible to continue to keep the facility in safe-layup status for an indefinite period of time. During the period, use of the office and laboratory wing would be restricted (see Fig. 4), but the use of the reactor room itself would be severely restricted because of the presence of experimental apparatus, the large shield structure, and above-normal radiation levels. The increased cost of maintaining the room in this condition would include maintenance of the entire building, building systems, and security, as well as costs for the health-physics monitoring of the building and its surroundings. Holding the reactor room in a layup condition would preclude the use of this space indefinitely.

An additional disadvantage of maintaining the facility in its present state is the possibility that the presence of radioactivity within the containment building would continue to be a hazard thoughout many decades. The legacy of removing it would be passed on to the future.

For the above reasons, the no-action alternative is considered inferior to the preferred alternative.

3. AFFECTED ENVIRONMENT

3.1 LOCATION AND DESCRIPTION OF THE SITE

ANL occupies a 690-ha (1700-acre) tract in Du Page County, Illinois, about 35 km (22 mi) southwest of downtown Chicago, and 40 km (25 mi) due west of Lake Michigan. It is in the Des Plaines river valley, south of Interstate 55 and west of Illinois Highway 83. The Laboratory and support facilities occupy about 80 ha (200 acres), with the remaining 610 ha (1500 acres) devoted to forest and landscape areas within the site perimeter. A map showing the relation of the Laboratory to the Chicago metropolitan area is given in Figure 1. Figure 2 illustrates the internal site arrangement and the location of Building 330 and the CP-5 reactor within the 300 area of the ANL site.

3.2 LAND USE, DEMOGRAPHY, AND CULTURAL RESOURCES

ANL is a multiprogram laboratory with research, development, and demonstration activities in five major scientific and technical areas: physical research, high-energy physics, biomedical and environmental research, energy and environment, and engineering research and development.

The scientific activities of these programs are conducted by engineers and scientists and are supported by many service and support personnel. As of January 1980, the total onsite population at ANL (personnel working on a full-time basis) was 5292, as shown in Table 1. More detailed information concerning site description and land use may be found in ANL (1979a).

A cultural-resource survey has been made on part of the ANL property (Fig. 3) and cultural-resource sites were identified by a program of shovel testing along transects of varying widths. Remains of three historic sites were located, which date to the late 19th/early 20th centuries. Eighteen prehistoric sites were identified and are primarily Late Middle Archaic/early Late Archaic, although an early Late Woodland component has been identified at one site. As a group, some of or all the prehistoric sites have been determined to be potentially eligible for inclusion as a district in the National Register of Historic Places.

The 300 area of the laboratory was not included in the areas investigated by field survey. However, most of the prehistoric sites that have been identified on the ANL property were reported in the ecology plots located in the southwest quarter of the laboratory site, which surrounds the 300 area. Therefore, the possibility exists that presently unknown cultural-resource sites remain in or near the CP-5 area; some of the sites may be significant. Consequently, it may be concluded that all areas impacted by the disturbance and disruption of topsoil as a direct or indirect result of decommissioning CP-5 will be investigated for evidence of surface and subsurface cultural-resource sites. The State of Illinois Department of Conservation concurs with these findings. Any historic and/or prehistoric sites that are identified must be evaluated and afforded mitigation and/or protection. The proposed action is not expected to have any impacts on cultural resources outside the ANL boundary that are eligible for, or listed in, the National Register of Historic Places.

3.3 GEOLOGY, WATER USE, AND HYDROLOGY

3.3.1 Geology

The ANL site area overlies an approximately 30-m-thick deposit of glacial till on top of dolomite bedrock. This bedrock, Niagaran and Alexandrian dolomite of Silurian age, is about 400 million years old. These formations are underlain by the Maquoketa shale of Ordovician age, and older dolomites and sandstones of Ordovician and Cambrian age. A detailed description of site geology may be found in ANL (1979a).

3.3.2 Water Use

Sawmill Creek is the principal stream that drains the site. It flows through the south portion of the Waterfall Glen Forest Preserve to the Des Plaines River. A detailed description of area water use may be found in ANL (1979a).

3.3.3 Hydrology

Groundwater supplies in the ANL area are derived from the Niagaran and, to some extent, the Alexandrian dolomite bedrock. Contaminants of groundwater at some places on the ANL site probably percolate slowly through the glacial drift, enter the Silurian dolomite, and can eventually enter ANL wells. The only suspected location on the site where groundwater could conceivably become contaminated and leave the site is along the southern boundary near the bluffs of the Des Plaines River. A detailed description of site hydrology may be found in ANL (1979a).

3.4 METEOROLOGY

The climate of the site is adequately described by meteorological-data summaries for 1950 to 1964 from the ANL weather station located about 750 m southwest of the reactor, and data for 1941 to 1970 from Chicago's Midway Airport 20 km east-northeast of the laboratory (Moses and Bogner 1967, ANL 1979a). The dispersive characteristics of the site have been calculated from three years (May 1975 through April 1978) of wind-speed and -direction data measured on the ANL 45-m meteorological tower, and the potential for severe windstorms at the site has been analyzed (ANL 1979a).

3.5 ECOLOGY

3.5.1 Terrestrial

The major soil types on the ANL site are of the Morley series, which are moderately well drained with low organic content in the surface layer, moderately low subsoil permeability, and large water-holding capacity. The site is within the Prairie Peninsula section of the Oak-Hickory Forest Region and is a mosaic of oak forest, oak savannah, and tall-grass prairie. Dominant plants are bluegrass and various forbs in the fields, and oak, hickory, ash, and cherry in the forested areas. Crown vetch has been planted extensively about the site for low-maintenance ground cover and erosion protection. Animals onsite are those species associated with secondary successional fields, forest, and forest-edge habitats, e.g. woodchucks, field mice, shrews, chickadees, crows, robins, and cottontails, and include an established herd of European fallow deer. A detailed description of the site terrestrial resources is available elsewhere (ANL 1979a).

3.5.2 Aquatic

Aquatic resources onsite include two confluent streams with several small impoundments, ponds, and cattail marshes (ANL 1979a). There is a network of drainage ditches that transports surface runoff to the streams to drain the majority of the site. These are small streams with fairly steep gradients (1.25% and 2.11%) and alternating riffle and pool configurations. The biotic communities are indicative of warmwater habitats receiving organic enrichment, e.g. low diversity, dominated by tolerant indicator organisms. Adjacent to the CP-5 site is a small (0.8-ha), deep (8-m), man-made pond fed by surface runoff (including that from the CP-5 area) and groundwater infiltration. During periods of high runoff, the pond may flood and drain into one of the site streams. A detailed description of the site aquatic resources is available elsewhere (ANL 1979a).

3.5.3 Endangered Species

The only endangered or threatened species that might be found on the ANL site is the Indiana bat (*Myotis sodalis*) (ANL 1979a).

3.6 RESULTS OF RADIOLOGICAL MONITORING BY ANL

The Occupational Health and Safety Division at ANL has conducted a program of environmental monitoring since 1948. An annual report is published containing the results of offsite and onsite monitoring of air, water, soil, and foodstuff samples, as well as gamma dosimeter data (Golchert et al. 1981).

In 1980, the average dose rate at 50 m (160 ft) to the southeast of CP-5 was 1820 mrem/yr, whereas at 45 m (150 ft) to the west it was 118 mrem/yr. The high reading is partially caused by previously activated material stored in the southeast quadrant of the CP-5 site; it is about 25% smaller than the reading in the same area in 1978 when the reactor was in operation. Based on actual measurements made in 1980, the offsite external penetrating radiation dose averaged 90 mrem/yr in the region extending out to 24 km (15 mi). This is essentially the same dose rate as the United States average from natural and global man-made sources.

Although substantially less than 1 Ci of long-lived radionuclides was released to the atmosphere during 1980, 9 Ci of ^{3}H were released from CP-5 and 5 Ci of ^{85}Kr were released from other sources at ANL. The release of 9 Ci of ^{3}H was due to tritiated water that continued to be emitted from the CP-5 stack. The 1980 monitoring-station readings for ^{3}H indicate only a very slight difference between offsite and onsite concentrations. The change in activity of ^{3}H effluent from 1979 to 1980 is 660 Ci to 9 Ci, corresponding to estimated maximum-individual population doses of 0.02 mrem/yr to 0.0002 mrem/yr, respectively.

Similar decreases were noted in 1980 for ^{3}H in the Sawmill Creek effluent. Only 1.6 Ci of ^{3}H were released to the creek in 1980. Less than 1 Ci of other radionuclides was released to the creek in 1980 from all operations at ANL.

4. PLANNED DECOMMISSIONING ACTIVITIES

To assess the environmental impacts of dismantlement, each major step in the procedure (as outlined in Table 2) has been examined in detail with reference to each component that is to be removed from Building 330 to a waste-disposal facility. A general plan of the building is shown in Figure 5. The process of examination is briefly described in Section 4.1, and the specific analyses are given in Appendix B. The estimated radiological impacts of handling each component are discussed in Section 5 and tabulated in Tables 6 and 7, and are used for summarizing the assessed impacts for the dismantlement process, as well as the mothball, entombment, and entomb-bioshield-only alternative processes. General procedures that need to be considered in arriving at the total of environmental impacts are defined in Sections 4.2, 4.3, and 4.4.

4.1 DEFINITION OF TOPICS USED IN IMPACT EVALUATION

In the Appendix B discussion, five major topics are addressed for each of the major tasks to be accomplished during the decommissioning of the CP-5 reactor.

4.1.1 Technique

This is defined as the means expected to be employed to accomplish the decommissioning tasks. As decommissioning proceeds, and as precise estimates of the nature and quantities of radioactive materials become better defined, other techniques may be substituted for those discussed here. The choice of technique will include considerations of the reduction of estimated environmental impact, time to accomplish the tasks, costs, and mitigation capability.

4.1.2 Releases

These are descriptions of any hazardous gaseous, liquid, or particulate materials expected to be released to the public environment as a consequence of decommissioning. Discharges to both air and water will be maintained within emission standards by use of mitigative measures discussed in Section 5.1.3 and Appendix B.

The only gaseous radionuclide to be released during any one of the decommissioning alternatives will be tritium in the form of tritiated water vapor released during operations involving the primary-coolant system and the lower shield assembly plug. The estimated quantities of release are based on the estimated quantities of residual heavy water remaining in the pipes, valves, pumps, and reactor vessel. Procedures for removal and disposal of the residual tritiated heavy water are described in Section 5.1.3 and Appendix B.

The particulate releases that are given in Appendix B are derived from estimates of quantities of (1) loose surface scale resulting from oxidation of the neutron-activated steel or aluminum parts that are to be transported through the reactor room and (2) the airborne particulates created by sawing metal or graphite within the reactor room. The estimates are based on the computations of activation products expected in the reactor components as of 1 October 1981, which are given in Table 4.

For estimating release from loose oxide, it is conservatively assumed that a 10-nm (100-angstrom) film has formed on either the activated aluminum or stainless-steel component parts and that 1% of the oxide layer is knocked loose and becomes airborne during movement of the component parts from the reactor shield structure to the reactor room. No credit is given for HEPA filtering during movement of the part, nor for filtering of building exhaust. (The Building 330 stack does not contain a HEPA filter.)

The methodology for estimating airborne sawdust in the tents constructed for mitigation is that given in Appendix J of NUREG/CR-0130, with modifications for estimated cutting rates. For all cases estimated it is conservatively assumed that the dust concentration will be as observed in the Elk River dismantling (United Power 1974), with a maximum of 10 mg/m^3, and that the airflow to an elephant-trunk evacuator will be 28 m^3/min (1000 cfm), permitting 280 mg/min of activated dust to reach the HEPA filter attached to the tent. Similarly, it is assumed that the release through the filter and to the public is 0.0005 of the airborne particulates.

The estimated airborne releases from the stack of Building 330 are summarized in Table 5, according to the principal tasks outlined in Table 2, for the dismantlement mode of decommissioning. A comparison of airborne releases among the four alternative modes considered for decommissioning is given in Section 5.

4.1.3 Mitigation

This is a description of the techniques or apparatus that will be used to mitigate the hazards inherent in accomplishing the decommissioning tasks.

4.1.4 Expended Time

Estimates of worker-time to complete the decommissioning tasks are made. These estimates are used to calculate the occupational exposures and to identify the most appropriate choices of decommissioning and mitigation techniques.

4.1.5 Dose

This consists of estimated cumulative occupational doses and calculated population doses that will occur as a result of accomplishing the decommissioning tasks. The estimates take into account the reduction of dose due to the use of mitigation procedures described for each task.

To estimate doses resulting from normal transportation of radioactive waste to the Hanford burial site, it is assumed that each truckload produces the maximum permissible dose rate of 10 mrem/h at 1.8 m (6 ft) from the external surface of a closed van. For the population dose, it is assumed that the truck (van) comes within 1.8 m of two persons per kilometer, or about 8000 persons per shipment. On the assumption that each person is exposed for one second, the cumulative dose per shipment will be about 22 person-mrem, or 5×10^{-6} person-rem/km.

In addition, it is conservatively estimated that 30 persons will pass within 1.8 m of the parked truck each hour and will be exposed for one minute. It is assumed that the stop time will be about eight hours per shipment.

For the occupational dose during transport, it is assumed that one driver will be exposed for 63 hours during each shipment. Thus, at the maximum permissible dose rate of 2 mrem/h, the cumulative occupational dose will be 126 person-mrem per shipment.

Calculations by Podlasek (1980) indicate that the number of radwaste shipments required for each of the four alternatives would be 187 for Alternative #1, 37 for Alternative #2, 37 for Alternative #3, and 131 for Alternative #4.

4.2 WASTE-HANDLING FACILITIES

4.2.1 Fuel-Reprocessing Facility

The spent fuel from the CP-5 reactor has been shipped to the DOE Savannah River Plant operated by E.I. DuPont de Nemours and Company, at Aiken, SC. The fuel-reprocessing facility includes two chemical-separation plants, one for extracting ^{239}Pu, and the other for ^{235}U and other special nuclides. This facility was established in the early 1950s to produce plutonium and ^{3}H for the U.S. Department of Defense. At the present time, the waste material from the reprocessing is concentrated, neutralized, and stored as a liquid in special tanks designed for long-term storage. Ultimate disposal will be as a solidified high-level waste in a form for geologic disposal.

4.2.2 Heavy-Water Facility

Most of the heavy water from CP-5, D_2O plus $^{3}H_2O$ impurity, has been transferred to the 400-area Heavy Water Facility at the Savannah River Plant. The water remaining in the primary-coolant lines will be similarly contained in 55-gal drums of stainless steel and shipped to the facility. The received water remains in storage for six to eight weeks before it is purified by removing chemicals and particulates other than D_2O or $^{3}H_2O$; i.e. the tritiated water is not separated from the D_2O. The water contamination is removed by stages of filter treatment and distillation to greater than 99.75% D_2O. The purified heavy water is stored in clean stainless-steel drums at the facility and will be used in other reactors when needed; i.e. heavy water is never treated as a waste product, even with large ^{3}H concentrations.

4.2.3 DOE Hanford Solid-Waste-Storage and -Disposal Facilities

All solid radioactive waste will be shipped to the waste-storage and -disposal operation in the 200 area of the DOE Hanford site, Richland, WA. This is part of Rockwell Hanford Operations, which includes fuel reprocessing, waste management, and all support services at the Hanford site. Appropriately packaged and labeled solid waste is buried in trenches. Routine trench burials are made for those containers that emit radiation at less than 100 mrem/h and, therefore, do not require special scheduling. Packaging will be carried out at ANL to meet the routine-loading specifications and to prevent the collapse of the containers after burial. The containers must have the approval of the Rockwell Packaging and Shipping Authority. The trenches are backfilled immediately with sufficient soil to reduce the dose rate at the edge of the trench to 100 mrem/h; the containers are eventually covered with 2.5 m (8 ft) of soil.

When the capacity of a burial site is exhausted, additional soil backfill is provided to reduce surface radiation to less than 0.5 mrem/h. All deactivated disposal sites are inspected at least semiannually to assure that specifications, as stated in Anderson and Poremba (1981), are maintained. During FY 1980, the total volume of nontransuranic radioactive material buried was 10,416 m^3 (Anderson and Poremba 1981).

4.3 WASTE-TRANSPORT PACKAGING

Offsite shipments from ANL are arranged by ANL, and it must verify that packaging meets all Federal regulations. These regulations are found in the Code of Federal Regulations, Titles 10 and 49, which specify the radiation contamination (10 CFR 20), the package integrity (10 CFR 71), and the types of packages that may be used for transport (49 CFR 170-189).

The types of packages that will be used for burial at the Hanford site will depend on the volume and shape of the material and will consist of 55-gal and 30-gal stainless-steel drums, the M-3 bin that is widely used at ANL, and other special custom-made bins to accommodate odd-sized or large objects. The drums (designated as DOT-17C and DOT-17H) have been approved for burial by the Rockwell Packaging and Shipping Authority.

Shipping containers consist of the DOT-17C and DOT-17H stainless-steel drums, described above, and the following cask-type containers and bins:

- Shielded "coffin" - This container will be used for onsite transfers and is constructed of steel with a lead core. Two types will be used: The larger (about 3 m or 10 ft tall), for fuel elements, has a vertical axial cylindrical hole about 10 cm (4 in) in diameter, and is surrounded by about 30 cm (12 in) of lead; the smaller (about 2.5 m or 8 ft tall), for shim safety rods, has a vertical axial cylindrical hole about 25 cm (10 in) in diameter, and is surrounded by about 10 cm (4 in) of lead. Both coffins are 1 m (3 ft) in diameter.
- Low-specific-activity (M-3) bin - This container will be used for onsite use or offsite shipping. It is constructed of 12-gauge steel, and its dimensions are 150 cm (58 in) wide, 130 cm (50 in) long, and 180 cm (72 in) high. The bin is equipped with a gasketed steel cover and lifting straps that are about 2 cm (3/4 in) in diameter. This container is of sufficient integrity to meet DOT requirements and can be made to qualify as a DOT-7A container.
- Drum pot - This container will be used for onsite transfers. It is sized to contain a single 55-gal drum in a central cavity. The pot is

constructed of steel with a lead core, and is fitted with a lead-shielded cover. Drums intended for offsite shipment will first be transferred from drum pots to other shipping containers, such as the "half super tiger" described below.

- Large shipping bin ("half super tiger") - This container will be used for offsite shipping. It is designed to protect radioactive materials from shock and fire damage during transportation, and is constructed of steel, aluminum, and fire-resistant foam. The cavity, a shielded cask, is made of 8-cm (3-in) -thick lead. The approximate outside dimensions are 2.5 m (8 ft) wide, 2.5 m (8 ft) long, and 3.3 m (11 ft) high. Depending on the volume to be shipped and on internal shielding arrangements, a payload of from 1400 kg (3000 lb) to 7300 kg (16,000 lb) can be accommodated. The casks are made by Nuclear Engineering, Inc. and are certified with DOT Permit No. 6679.
- "HFIR" cask (irradiated fuel element shipping cask) - This container was used for shipping of irradiated fuel elements and may be used for the converter cylinders (described in App. B, Sec. B.1). It is constructed of two concentric stainless-steel cylinders with 1.3-cm (1/2-in) walls, with the cavity between them filled with 23 cm (9 in) of lead. The inside of the cask is outfitted with a rack that can accept 17 fuel elements containing up to 1.4 million Ci of mixed fission products. Cadmium "poison" is incorporated in the rack to prevent nuclear reactivity from occurring. Dimensions are 117 cm (46 in) in diameter and 168 cm (66 in) high. Thermal radiating fins on the cask permit the designed dissipation of 3.75 kW (12,800 Btu/h). This cask is certified with DOT Certificate of Compliance No. 5507.

All shipments of radioactive waste will be in compliance with Federal, state, and local regulations. Regulations in 49 CFR, issued by DOT, state the following upper limits for dose rates at specific distances from vehicles used exclusively for radioactive waste:

- 1000 mrem/h at 0.9 m (3 ft) from the external surface of the package,
- 200 mrem/h at any point on the external surface of the vehicle,
- 10 mrem/h at 1.8 m (6 ft) from the external surface, and
- 2 mrem/h at any normally occupied position in the vehicle.

ANL will use one of several commercial companies that have special capabilities for hauling radioactive wastes. Formal accident-control and -recovery plans will be developed before the first shipments to the Hanford site are made.

4.4 RADIOLOGICAL MONITORING

4.4.1 Waste Classification

All solid radioactive wastes will be sent to the Hanford site for disposal. Solid waste with surface radioactivity detectable using state-of-the-art instrumentation (thin sodium-iodide detectors and gas-flow proportional counters) will be classed as radioactive waste.

Liquid radioactive effluent, such as cleaning solutions and acid etching baths, will be trapped in the building sump reservoirs and disposed of onsite by standard procedures used for reclamation services at ANL. The procedures generally involve evaporation of the liquid and mixing of the evaporator bottoms with vermiculite to ensure that the eventual shipment to burial facilities contains no liquids.

Nonradioactive waste, i.e. materials with surface radiation that is not detectable using state-of-the-art instrumentation, will be buried in landfills either on the ANL site or at commercial landfills near the site. The extent of final decontamination of the building for unrestricted use will be based on the final remodeling plans discussed in Appendix B, Section B.52, and on the definition of dose rates for unrestricted use that will be appropriate at the time. These limits are to be established by the U.S. Environmental Protection Agency (NRC 1981). The estimated quantity of nonradioactive waste is given in Table 6.

4.4.2 Radiological Monitoring During Decontamination and Decommissioning

The ANL Occupational Health and Safety Division will be responsible for monitoring of radiation levels at each component to be dismantled and the airborne radiation within the building, on the ANL grounds, and at offsite stations. It will supervise the operation and counting of dosimeters worn by personnel and will monitor all surfaces within the reactor room and on vehicles.

5. POSSIBLE ENVIRONMENTAL CONSEQUENCES OF DECOMMISSIONING ACTIVITIES

The environmental impacts of the decommissioning activities are briefly discussed in this section and are summarized in Tables 6 and 7. The principal estimated adverse impacts are radiological doses to the public and to the workers, the effects of transporting quantities of radiological waste and storing it at a remote burial site, and the possible effects of ground disturbance on the archeological sites that may exist within the small area around the reactor building. The estimated impacts are tabulated to compare the effects to be created by the preferred action (Alternative #1), which is total dismantlement of the reactor, with Alternatives #2, #3, and #4, described in Section 2. Any of these four alternatives would provide some additional space for office or laboratory use.

5.1 NONRADIOLOGICAL

5.1.1 Land Use

Each alternative for decommissioning the CP-5 facility will release about 1.2 ha (3 acres) of previously restricted land around Building 330 for unrestricted use. However, it is probable that only full dismantlement (Alternative #1, Sec. 2.1) will provide unrestricted use of the building interior. The estimated use of land for shallow waste burial at the Hanford site is shown in Table 6. The wastes from dismantlement will occupy about 280 m^2 (3000 ft^2), compared to 40 m^2 (450 ft^2) for mothballing. This difference is small compared to the unrestricted building space gained by dismantlement. As of 31 December 1980, the burial grounds in the Hanford 200 area covered 80 ha (200 acres) or 0.8 million m^2 (8.5 million ft^2); thus, the waste from dismantlement of CP-5 would occupy about 0.04% of that area. The amount of nonradioactive waste generated is minimal compared to all other wastes disposed of at landfills in the counties surrounding the site.

5.1.2 Cultural Resources

The possibility exists that cultural resources could be located beneath the surface of the waste-storage yard of the reactor facility or beneath the foundations of structures to be demolished (see Fig. 4), as these areas remained unsurveyed at the close of the 1981 field season. Because these activities could include some ground-surface disturbance, any resources that are present could be disturbed. Sufficient notice will be provided to a qualified archeologist prior to any ground disturbance so that preparations may be made for an examination of areas to be disturbed. Should cultural resources be identified, appropriate mitigative measures may be necessary (Curtis and Berlin 1980). The Illinois Department of Conservation has been consulted and is in agreement with the necessity for a survey prior to disturbing the surface area.

5.1.3 Water Quality and Use

The CP-5 facility is fitted with a sump system. Any radioactive liquids (e.g. cleaning solutions) that escape during decommissioning will be collected in the sump for disposal at the end of decommissioning. Inasmuch as the sump water presently contains radioactivity, it will not be discharged to natural waters, but its entire contents will be disposed of as radioactive waste by ANL reclamation services. The usual technique of evaporation to a radioactive solid cake will not be used for tritiated liquids. If ^3H is the only contaminant, the tritiated liquid will be diluted to less than 3 nCi/cm^3, the maximum permissible level, before its release as storm-sewer effluent.

5.1.4 Air Quality

Because of the tent shelters that will be erected, nonradioactive dust clouds from demolition within Building 330 will not impact the quality of the outside air. However, some dust will be mobilized during the razing of the vapor sphere, two concrete time-of-flight stations, a liquid-nitrogen storage building, and an air-scrubber facility, and during cleanup of the waste-storage yard. The amount of dust will be typical of that from demolition and cleanup operations involving small to moderate commercial or industrial facilities. It is expected that, on occasion, the quality of the ambient air will be degraded by the dust. This is considered to be a potential adverse impact of minor consequence.

The possible release of asbestos fibers from demolition of outside structures containing "Transite" sheeting or siding will be prevented by removing the sheets as whole pieces, so that shredding will not occur. Pipe wrapping from exterior and interior pipes will be carefully packaged on the site to prevent fiber releases to the workers or to the public.

5.1.5 Terrestrial Biota and Endangered and Threatened Species

It is intended that Building 330 will not be removed as a consequence of decommissioning the CP-5 reactor, but will be put to other uses. Thus, no ecological changes will occur on the land occupied by the structure. Although the waste-storage yard is in a disturbed state, it presently provides habitat for some terrestrial plant and animal life (Sec. 3.5.1). Decommissioning activities will cause further disturbance involving damage to and removal of some plants, disturbance and/or injury or death of some animal life, and partial exclusion of mobile animals such as some birds and rodents. Inasmuch as new uses for the yard have not yet been decided, it is not possible to evaluate whether the biotic damage will eventually be reversed. In any event, the area of the yard is very small (about 1 ha or 2 acres) in relation to the amount of similar habitat in the ANL site and local area; hence, the adverse impact of decommissioning the yard, even if locally great, will be negligible in terms of the ANL and local-area ecosystems. The Indiana bat will not be threatened by these minor ecosystem changes, especially in view of the fact that the CP-5 area is not generally suitable to the habitat needs of bats.

5.1.6 Socioeconomics

Inasmuch as no more than 50 additional persons will be onsite during the decommissioning activities at CP-5, the socioeconomic impact on the area around ANL will be negligible. These additional workers are likely to come from the local labor force, thus further minimizing the social impact.

5.2 RADIOLOGICAL

5.2.1 Nonoccupational Doses

5.2.1.1 Methodology

The radiological assessment of the decontamination and decommissioning of CP-5 was made by estimating the possible radioactivity releases from the four different alternatives (Table 6), computing dispersion using site meteorology and a Gaussian plume-dispersion model, and computing the radiation doses to nearby individuals as well as the general population within 80 km of CP-5. The dispersion computation was done using computer code XOQDOQ, which is used by NRC in its meteorological evaluation of routine releases from commercial nuclear power plants. The GASPAR code, which is used by NRC to evaluate radiological impacts of light water reactors, was used to compute radiation doses.

5.2.1.2 Source Terms and Exposure Pathways

The methodology for estimating source terms is given in Section 4.1.2. The source terms for dose calculations are given in Table 6 for the four alternatives that would achieve the objective of providing useful building space. For the mothball and entomb-total alternatives (#2 and #3), it is expected that 12 Ci of tritium would be released. For the dismantlement and entomb-bioshield-only alternatives (#1 and #4), it was estimated that 12 Ci of tritium, 0.045 Ci of ^{60}Co, 0.044 Ci of ^{55}Fe, and 0.004 Ci of ^{63}Ni would be released.

Population-exposure pathways calculated include inhalation and vegetable, meat, and milk ingestion. For the individual receptors, inhalation was the only pathway considered significant. Although it is possible and likely that the individual receptors would also eat food grown within the 80-km radius, the additional radiation dose is expected to be negligible. More than 99.9% of the incurred food-pathway dose is due to ^{60}Co and more than 99% of the ^{60}Co dose is due to direct exposure to ground-deposited radioactive material. The input milk-, meat-, and vegetation-production parameters for the calculations of the food-pathway doses are taken as the average for Illinois, as given in the June 1977 publication of GASPAR.

5.2.1.3 Receptors and Radiation Doses

For the purposes of assessing effects of radioactivity releases, radiation doses were calculated for the population within 80 km of CP-5. Included in this population are ANL workers who are not directly involved in the decontamination and decommissioning of CP-5. The nearest individual to CP-5 is expected to be an ANL employee who works at Building 301. This nearest individual is assumed to be working outdoors at the time when the releases occur.

Whole-body and lung doses were calculated for each alternative. The lung dose from each nuclide is generally the highest among the organ doses. The radiation-release estimates (source terms), and hence the calculated radiation doses for the dismantlement and entomb-bioshield-only alternatives (#1 and #4), are identical. Similarly, the calculated doses for the mothball and entomb-total alternatives (#2 and #3) are the same.

For Alternatives #1 and #4, whole-body and lung doses for the maximum exposed individual would be 0.02 mrem and 0.2 mrem, respectively, and the population dose would be 8.33 person-rem. The estimated doses from the release of ^{239}Pu are on the order of 10^{-6} person-rem for the maximum individual dose and 10^{-6} person-rem for the cumulative population dose. Thus, the presence of plutonium in the isotope train (see App. B, Sec. B.19) should have no significant impact on the environment. For Alternatives #2 and #3, whole-body and lung doses would both be less than 0.01 mrem for the maximum exposed individual, and the cumulative population dose would be 0.0016 person-rem. These doses may be compared with background external-radiation dose rates measured in towns surrounding the ANL site. The measured background dose rate averaged 90 mrem/yr (Golchert et al. 1981). This value, when applied to a population of 7,948,000 within 80 km of ANL, yields a population dose of 715,000 person-rem/yr. The radiation doses are summarized in Table 7.

5.2.2 Occupational Doses

Over the operating lifetime of CP-5, reactor materials and associated equipment have accumulated radionuclides through the neutron activation of certain nuclides, plating out of fission products in the primary system, leakage of contaminated heavy water, and, in one case, contamination by an experimental sample of plutonium. As discussed in Section 4 and Appendix B, operations to dismantle and decontaminate certain components of the reactor will result in the mobilization of some of these radionuclides. The concentrations of alpha, beta, and gamma emitters in the work environment, and the resulting dose therefrom, will depend on the amounts of various radionuclides on components and the orientation of these components with respect to the work areas.

Workers decontaminating and dismantling the reactor will be exposed to gamma radiation from activation and fission products remaining in the reactor and associated equipment during much of the work. They may inhale and absorb through skin some tritiated water during various operations, but this will be mitigated by various means including the use of local ventilation, as discussed in Section 4 and Appendix B. However, if these techniques are insufficient to reduce doses to the levels given in Table 7, other mitigative strategies, including the use of supplied air, will be used.

Dust and flakes of radioactive material will be generated while dismantling components such as the biological shield, the graphite reflector and other graphite components, contaminated thimbles (including the plutonium-contaminated thimble), and corroded radioactive assemblies. Particle inhalation by workers is not expected to be significant because mitigative measures will be used, including the use of local ventilation, and respirators or supplied air when warranted.

Distance and the use of protective clothing will shield workers from external beta radiation; thus, the dose to workers from this radiation is expected to be insignificant compared to the dose from external gamma radiation.

Estimated exposure rates from various radioactive materials in the reactor are discussed in Appendix A and listed in Table 8. Estimated worker-times in radiation areas, dose rates, and cumulative whole-body occupational doses for jobs involving specific reactor components are given in Appendix B. The estimated cumulative whole-body occupational doses for each of four alternative decommissioning modes are given in Table 7. For dismantlement, a total occupational dose of about 21 person-rem is estimated.

5.2.3 Transportation Doses

The estimated population doses resulting from normal transportation of radioactivewaste from ANL to the Hanford site are based on a total dose per shipment of 22 person-mrem, as derived in Section 4.1.5. For Alternative #1 (requiring 187 shipments), the estimated cumulative population dose is 4 person-rem, or almost 50% of the cumulative population dose within 80 km of the site. However, for Alternatives #2 and #3 the transportation doses are two orders of magnitude larger than the very small population doses due to decommissioning activities at the site, as given in Table 7.

For occupational transportation doses, using the methodology given in Section 4.1.5, 24 person-rem is estimated for Alternative #1. For Alternatives #2 and #3, the occupational transportation doses exceed the very small onsite occupational doses (Table 7). The volumes of radioactive material to be transported are presented in Table 6 (ANL 1980, Brooks 1978, Moe 1980, Podlasek 1980, Schulke 1978, Zorman 1980).

5.3 ACCIDENTS

5.3.1 Onsite events

Inasmuch as dismantlement involves the use of heavy-lifting equipment and complex power tools, it could be expected that occupational injuries and deaths might occur. However, experience to date with dismantlement of other nuclear facilities indicates that the careful planning of each operation, with the high priority of safety, has the effect of limiting accidents during decommissioning to very minor events.

For example, during the three years for dismantlement of the Elk River reactor there were no disabling or lost-time injuries during 250,000 man-hours of work for the parent-company employees and considerably more man-hours of subcontractor work (United Power 1974). A similar record was achieved during the dismantlement of the Ames Laboratory Research Reactor (Voigt 1981). In the latter case, the principal unexpected impediments involved minor dispersals of radioactive dust from certain of the inner components. Thus, it would appear that a realistic estimate of lost-time accidents from onsite operations would be that none are expected if proper planning is practiced and precautions are taken to eliminate sources of fire and explosion. Neither flame torching nor blasting are planned; thus, the primary source of accidents would appear to be possible fires or explosions in gasoline or liquid-petroleum-gas engines in trucks used for hauling equipment.

The possibility of dispersal of radioactivity from natural disasters such as tornados, earthquakes, or floods is equally remote. The possible maximum doses from such disasters are very limited because the fuel and the bulk of the heavy water have been removed. In addition, the very low frequency of such events and the safety features in the building construction make it implausible to expect penetration of either missiles or water, or building destruction, during the short time involved in decommissioning. The risk from natural disasters is estimated to be insignificant.

5.3.2 Transportation Accidents

From published accident statistics (AEC 1972, Battelle 1975, Russell 1974), the probability of a truck accident is in the range of 1.0 to 1.6×10^{-6}/km (1.6 to 2.6×10^{-6}/mi). DuCharme et al. (1978) have estimated the fractions of accidents of different severities. On the assumption that there will be a total of about 200 shipments--all to the destination of Hanford, 2900 km (1800 mi) from ANL--it has been calculated that the probability of one accident of any type is 0.62 for the duration of decommissioning and disposal. The probability that there will be an accident severe enough to release any radioactivity is less than 0.18, and the chance of releasing 10% or more of the contents of low-specific-activity drums or type-A packages in an accident is only about 0.03. In all cases, the waste will be solid; thus, the radioactivity will be in physical forms that are not easily dispersed (App. B). This further decreases the possibility of exposure to the public.

DuCharme et al. (1978) have estimated that even frequent shipments of radionuclides through a densely populated area (New York City) and related accidents during transport would result in small risk to the public. Because the route to Hanford is primarily through sparsely populated areas, and because the number of shipments will be relatively small, the radiological risk to the public due to transportation accidents involving CP-5 wastes is expected to be very small.

6. SUMMARY OF IMPACTS

6.1 UNAVOIDABLE ADVERSE IMPACTS

Dismantlement of CP-5 and the removal of radioactive material to a low-level-waste burial site will produce the relatively insignificant adverse impacts estimated in Tables 6 and 7. The radioactive airborne nuclides released will include ^{3}H, ^{239}Pu, ^{60}Co, ^{55}Fe, ^{63}Ni, and relatively minor quantities of others. The major population dose is 0.20 mrem to the lungs of a person working outside Building 301. This is to be compared with the average whole-body dose from natural-background radiation of about 90 mrem/yr at the ANL site and in nearby residential areas. The cumulative population dose due to onsite decommissioning activities for the 80-km radius is 8.3 person-rem for a population of 7,948,000. The cumulative population dose from transportation activities should not exceed 4.1 person-rem. The estimated occupational doses are 21 person-rem for dismantlement activities and 24 person-rem for transportation. There is no reason to expect any worker to incur an occupational dose greater than 3 rem/quarter, the allowable limit. The estimated risk from accidental exposure is insignificant.

The total land commitment for burial of radioactive waste is estimated as 280 m^2 (0.07 acre or 3000 ft^2). This area is insignificant compared the total low-level-waste burial-site area available and also compared to the office area and open space gained by the dismantlement.

The greatest nonradiological impact is due to the estimated 187 shipments of waste produced by dismantlement from ANL to the Hanford site. In addition to normal risks from truck accidents, the energy use and truck-engine emissions are adverse impacts that cannot be avoided, unless a disposal site at a closer destination is authorized.

It is not known whether ground disturbance in the outdoor waste-storage yard will cause destruction or change in any archeological sites. This possibility will be investigated before the disturbance occurs.

6.2 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

An estimated 280 m^2 (0.07 acre or 3000 ft^2) of land will be committed to burial of radioactive waste. The metallic radioactive waste can be retrieved after less than 100 years of decay in activity. Other valuable materials such as heavy water and unfissioned ^{235}U will not be discarded, but will be redistributed to other users, after purification and separation, respectively.

7. LIST OF AGENCIES AND INDIVIDUALS CONSULTED

The following agencies and individuals were consulted during the preparation of this environmental assessment:

Anderson, J.D., Rockwell Hanford Operations, Hanford, WA

National Park Service, National Register of Historic Places

State of Illinois, Department of Conservation

Voigt, A.F., Ames Laboratory Research Reactor, Ames, IA

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Zorman, J.R. 1980. "Volume of Material Left by CP-5 Users on the Reactor Floor as of February 1980." Argonne National Laboratory, memo to J.H. Talboy, 28 February

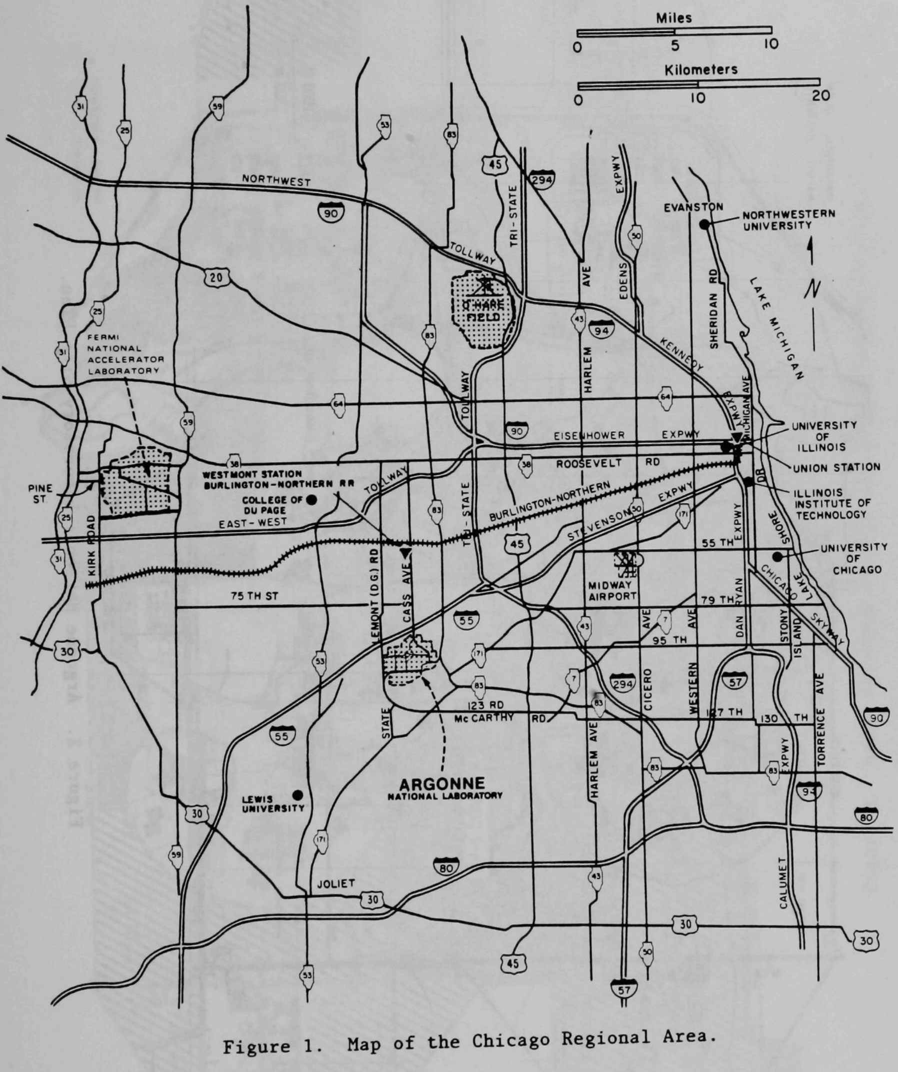

Figure 1. Map of the Chicago Regional Area.

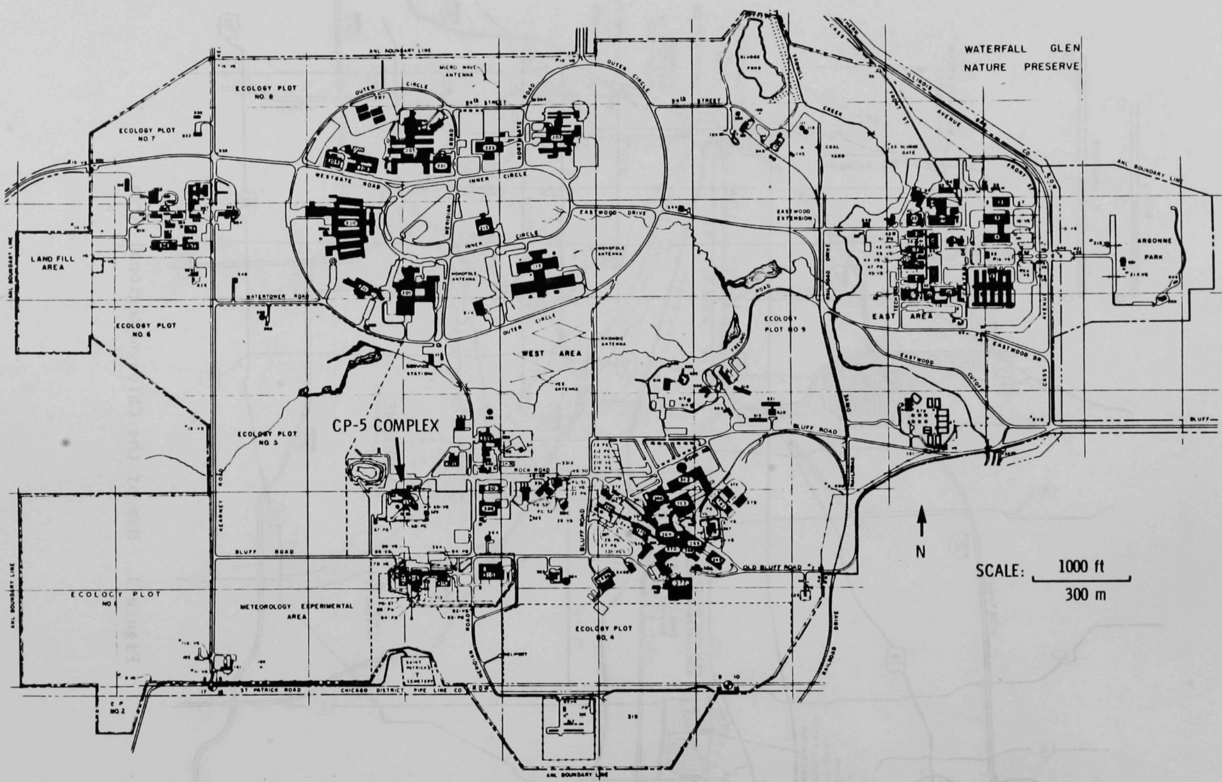

Figure 2. Argonne National Laboratory Site Plan.

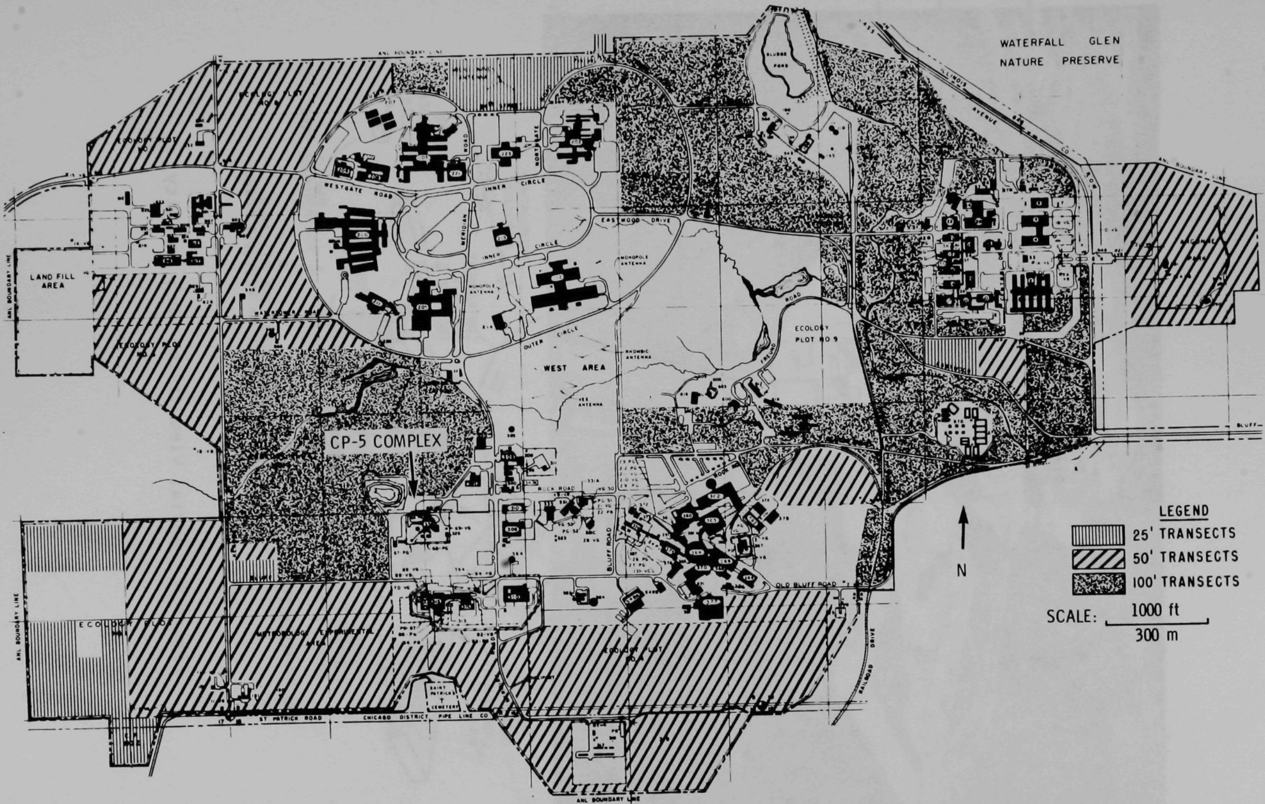

Figure 3. Areas Surveyed in 1978 and 1979 by Shovel Testing.

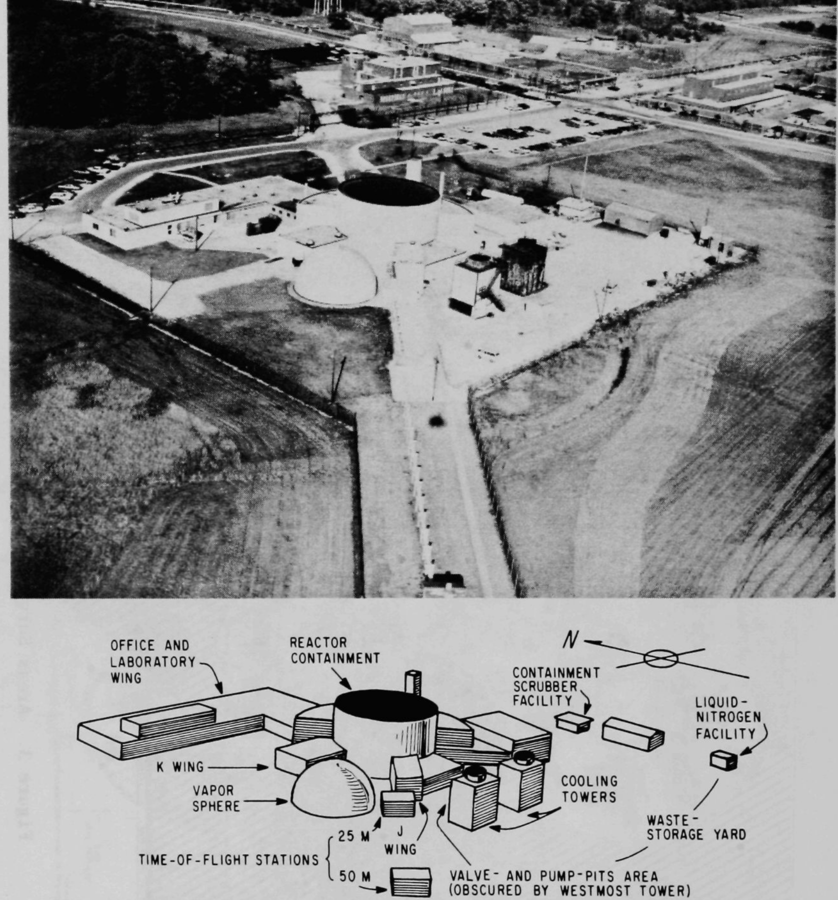

Figure 4. Aerial View of the CP-5 Facility.

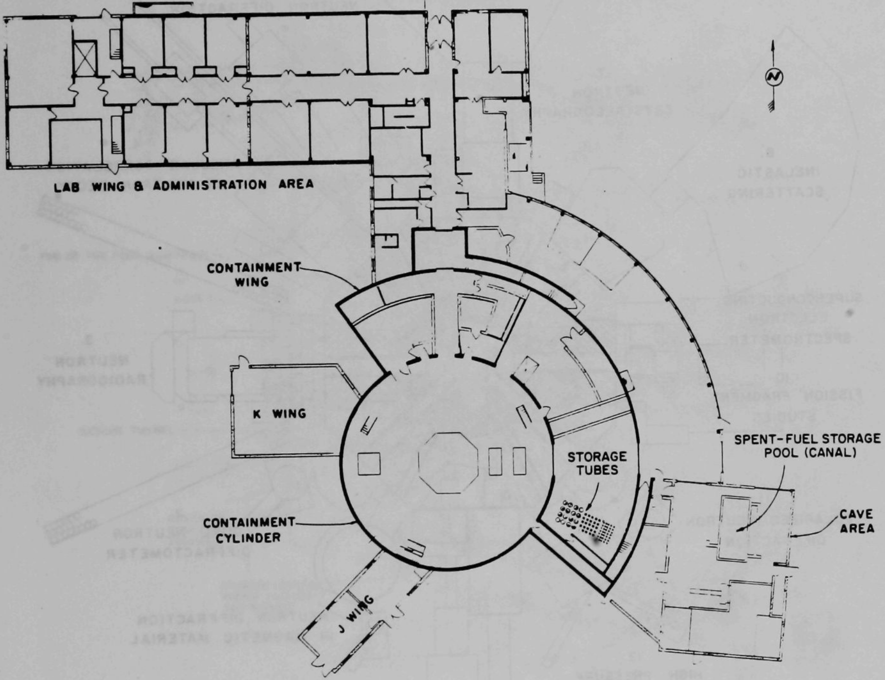

Figure 5. General Plan of the CP-5 Building.

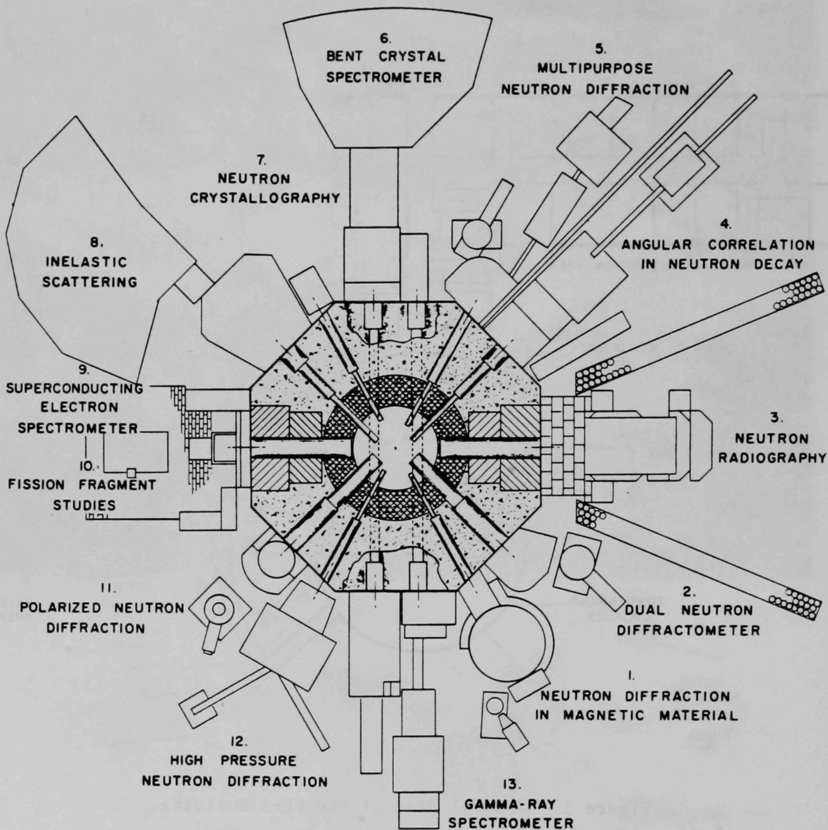

Figure 6. Plan View of the Reactor Experimental Floor.

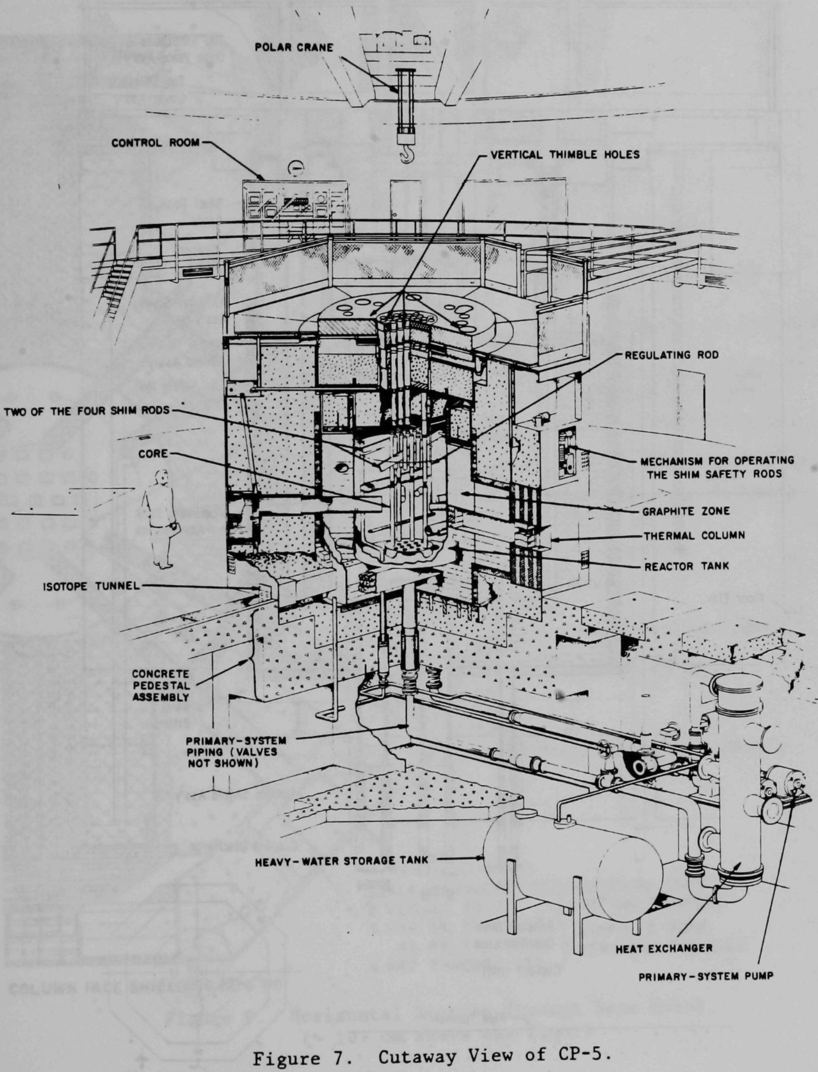

Figure 7. Cutaway View of CP-5.

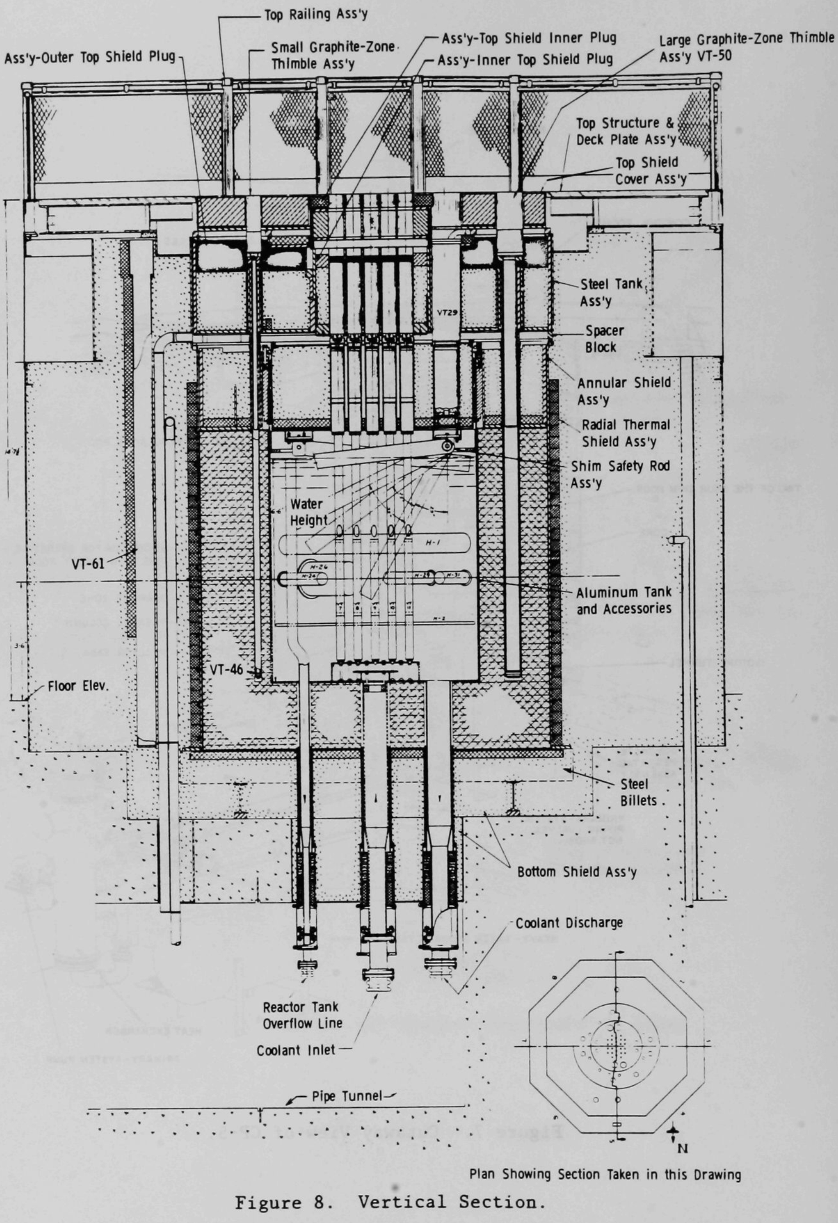

Figure 8. Vertical Section.

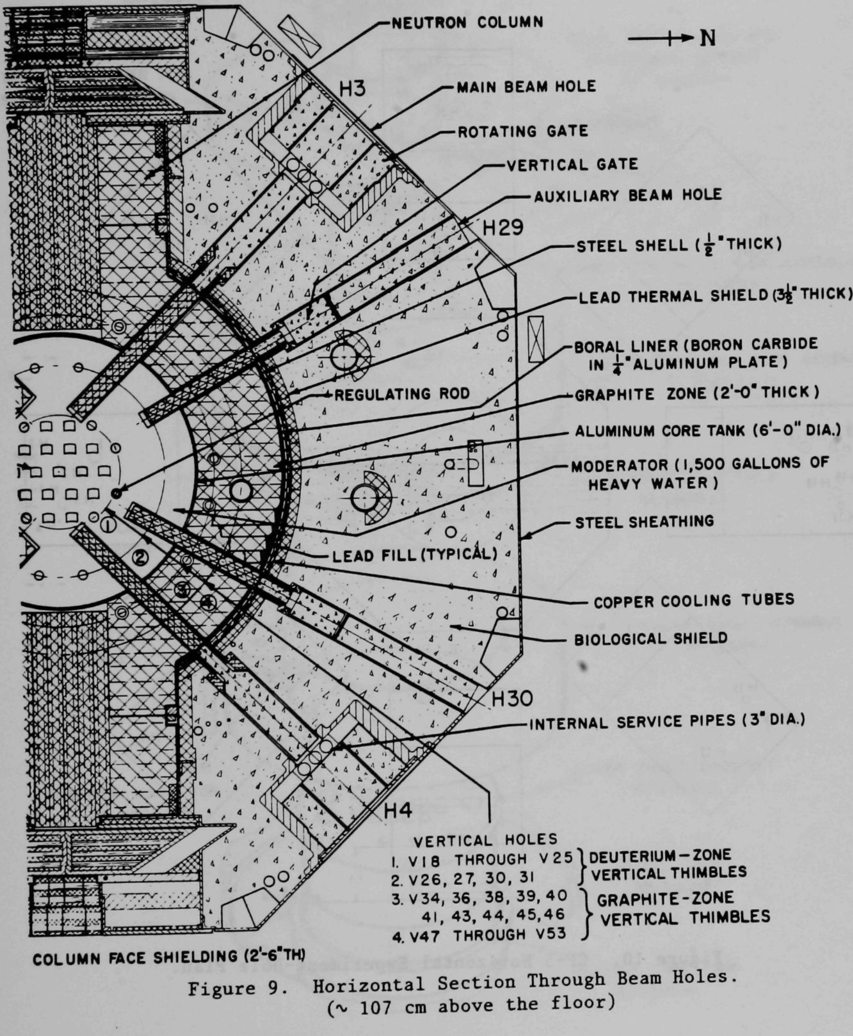

Figure 9. Horizontal Section Through Beam Holes. (~ 107 cm above the floor)

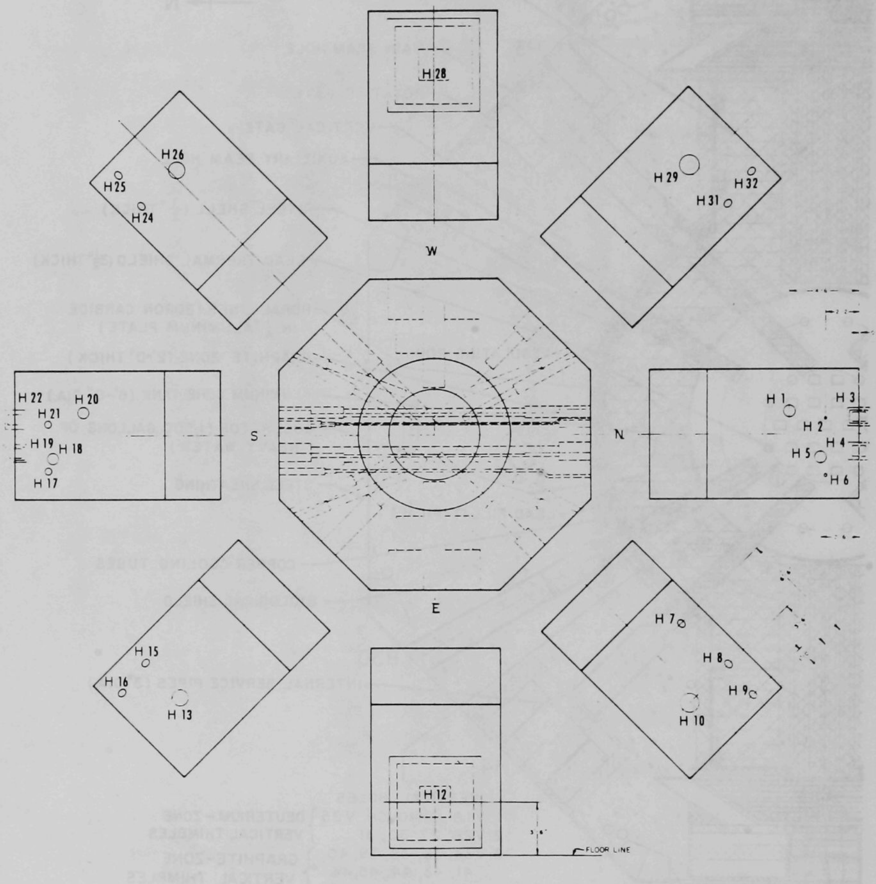

Figure 10. CP-5 Horizontal Experiment-Hole Plan.

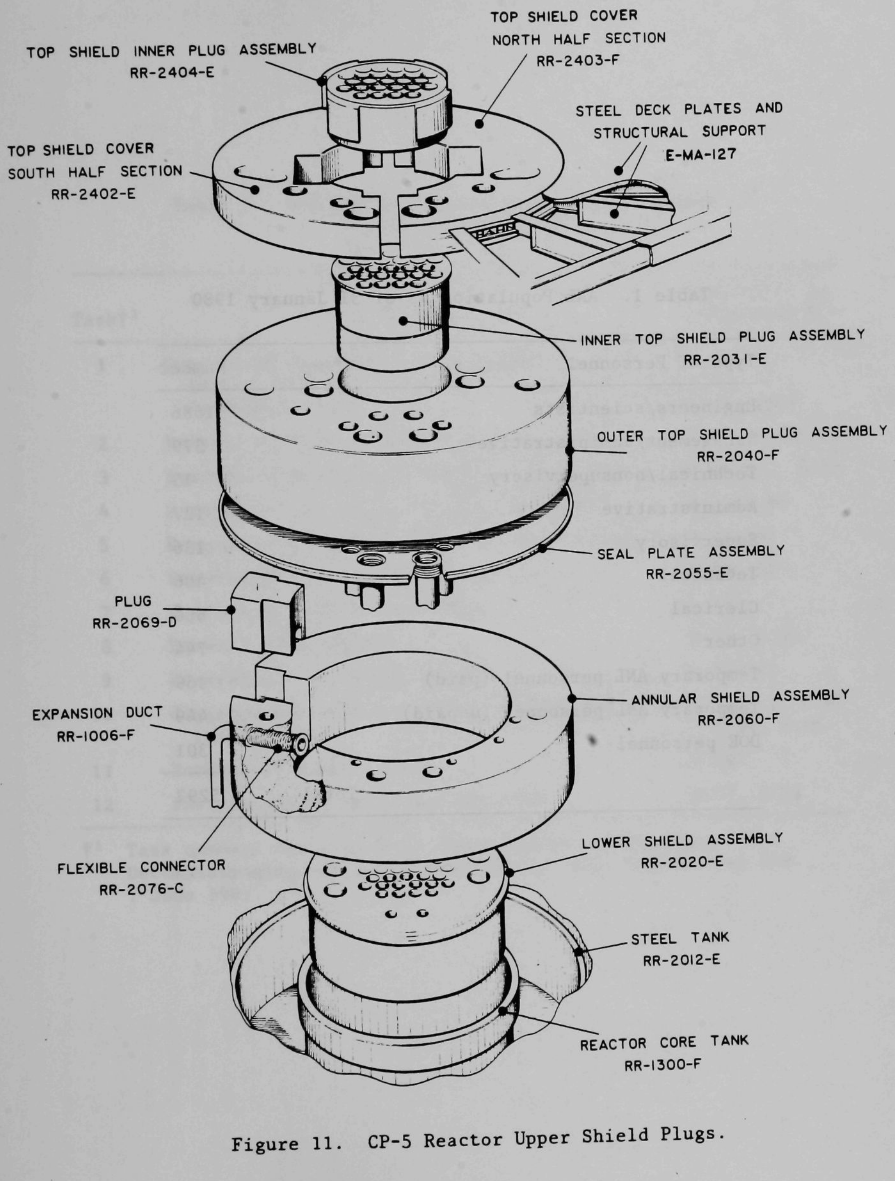

Figure 11. CP-5 Reactor Upper Shield Plugs.

Table 1. ANL Population as of 31 January 1980

Type of Personnel	Number
Engineers/scientists	1686
Management/administrative	579
Technical/nonsupervisory	15
Administrative	127
Supervisory	136
Technical	486
Clerical	600
Other	744
Temporary ANL personnel (paid)	169
Temporary ANL personnel (unpaid)	449
DOE personnel	301
Total	5292

Table 2. Outline and Description of Major Tasks in Dismantlement of CP-5

Task†[1]	Activity	Section(s) in Appendix B
1	Removal of experimental apparatus:	
	Within building	B.3
	In waste-storage yard	B.48, B.49
2	Removal of vertical facilities in reactor	B.4, B.23-.25
3	Removal of horizontal equipment in reactor	B.6-.22, B.37
4	Removal of ancillary reactor equipment	B.3, B.44
5	Removal of reactor cooling and gas system	B.43-.46
6	Removal of upper shield plugs	B.26-.34
7	Removal of reactor core tank	B.35
8	Removal of graphite	B.36, B.37
9	Removal of biological shield	B.38-.42
10	Cleanout of reactor equipment rooms and facilities	B.1, B.2, B.47 B.50, B.51
11	Removal of outbuildings	B.53
12	Restoration of buildings and site	B.51, B.52

†[1] Task numbers correspond to those adopted by Stevens, "CP-5 Decommissioning and Disassembly Plan," ANL, Engineering Div., 1 June 1981.

Table 3. Activity Schedule and Duration for CP-5 Decontamination and Decommissioning Field Work - Dismantlement Alternative

Elapsed Time (months): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36

Task†[1]	Activity
1	Remove experimental equipment from floor and outbuildings
11	Demolish outbuildings
10	Remove retention tanks
10	Remove rabbit lab
5	Remove primary cooling system and auxiliaries
5	Remove instrumentation (basement)
5	Remove electrical equipment (basement)
4	Remove ancillary reactor experimental equipment
10	Clean control room
2 & 3	Remove reactor experimental facilities (vert & horiz)
6	Remove top shield plugs
6	Remove inner shield plug
7	Remove aluminum tank
6	Remove lower annular plug
8	Strip thermal columns
8	Remove graphite
9	Remove steel and boral
9	Remove concrete and lead
10	Remove HVAC
10	Rod storage area
10	Cave and pool cleanup
12	Restoration activities

†[1] Adapted from Stevens, "CP-5 Decommissioning and Disassembly Plan," ANL, Engineering Division, 1 June 1981.

Table 4. Computed Activation Products in Reactor Components on 1 October 1981 (Ci)

Radionuclide	Aluminum: Reactor Vessel	Aluminum: In Tank and Beam Tubes	Stainless Steel: Tank and Beam Tubes	Stainless Steel: I Beams and Upper Plug	Regulating Rod and Shim	Graphite Zone and Thermal Columns	Lead Thermal Shield	Boral	Carbon-Steel Base Beams	Steel Shell	Concrete Biological Shield	Total
Co-60	9.3 E+4†[1]	3.5 E+4	1.4 E+5	5.7 E+4	1.0 E+3	5.0 E-1	-	9.1 E+2	3.0 E-1	1.4 E+1	4.1 E+0	3.3 E+5
Fe-55	1.4 E+3	5.4 E+2	2.9 E+5	1.1 E+5	2.0 E+0	1.8 E+1	1.0 E+0	4.9 E+1	1.0 E+0	2.7 E+1	1.2 E+2	4.0 E+5
Ni-63	-	-	2.9 E+4	1.0 E+5	-	-	-	-	-	3.0 E+0	-	1.3 E+5
Ta-182	5.3 E+2	2.0 E+2	-	-	6.0 E-1	-	-	5.0 E+0	-	-	2.0 E-3	7.4 E+2
Cd-113m	-	-	-	-	-	-	-	8.7 E+2	-	-	-	8.7 E+2
Ag-110m	5.3 E+1	2.1 E+1	-	-	1.0 E-1	-	1.8 E+1	5.0 E-1	-	-	1.9 E-4	9.3 E+1
Zn-65	2.1 E+1	8.0 E+0	-	-	2.3 E-2	-	7.0 E-1	2.0 E-1	-	-	1.0 E-1	3.0 E+1
Mn-54	1.7 E-2	9.2 E-3	1.7 E+1	5.2 E-2	-	-	-	-	1.3 E-3	2.8 E-3	1.3 E-1	1.7 E+1
C-14	-	-	7.0 E-1	5.7 E-3	-	2.8 E+0	-	2.1 E-4	-	-	2.7 E-2	3.5 E+0
Ca-45	-	-	-	-	-	2.1 E-4	-	-	-	-	1.8 E-4	3.9 E-4
Pb-205	-	-	-	-	-	-	1.8 E-3	-	-	-	-	1.8 E-3
Sn-119m	-	-	-	-	-	-	1.0 E-1	-	-	-	-	1.0 E-1
Sn-121m	-	-	-	-	-	-	3.6 E-3	-	-	-	-	3.6 E-3
Sn-113	-	-	-	-	-	-	1.0 E-3	-	-	-	-	1.0 E-3
Total												8.6 E+5

†[1] Exponential notation: 9.3 E+4 = 9.3×10^4.

Table 5. Summary of Estimated Radioactive Airborne Releases for Each Task (Ci)

	Nuclide				
Task†[1]	H-3	Co-60	Fe-55	Ni-63	Other
1	-	-	-	-	-
2	-	-	-	-	-
3	-	1.0 E-4†[2]	1.5 E-3	1.0 E-5	1.0 E-9 (Pu-239)
4	5.0 E+0	-	-	-	-
5	7.0 E+0	-	-	-	-
6	-	2.5 E-3	4.0 E-3	4.0 E-3	-
7	-	1.0 E-2	1.0 E-4	-	5.0 E-5 (Ta-182)
8	-	-	2.5 E-5	-	4.0 E-6 (C-14)
9 (boral)	-	2.0 E-3	8.0 E-5	-	2.0 E-4 (Ta-182)
9 (steel)	-	3.0 E-2	4.0 E-2	4.0 E-4	1.5 E-3 (Cd-113)
10	-	-	-	-	-
11	-	-	-	-	-
12	-	-	-	-	-

†[1] See Table 2 for task descriptions.

†[2] Exponential notation: 1.0 E-4 = 1.0×10^{-4}.

Table 6. Major Impacts of Alternative Modes of Decommissioning CP-5

	Decommissioning Alternative			
Impact	#1 Disman- tlement	#2 Mothball	#3 Entomb Total	#4 Entomb Bioshield Only
Provide building space	Un- restricted	Restricted	Restricted	Restricted
Surveillance costs	None	As is	As is	Small
Airborne radionuclide releases to public (Ci):				
H-3	1.2 E+1†[1]	1.2 E+1	1.2 E+1	1.2 E+1
Co-60	4.5 E-2	0	0	4.5 E-2
Fe-55	4.4 E-2	0	0	4.4 E-2
Ni-63	4.0 E-3	0	0	4.0 E-3
Pu-239	8.0 E-10	0	0	8.0 E-10
Nonradioactive dust	Interior and exterior	Exterior only	Exterior only	Exterior only
Radwaste volume (m^3):				
Concrete	175	0	0	Small
Lead	4.8	< 0.2	< 0.2	4.8
Graphite	24.6	0	0	24.6
Stainless steel	5.5	< 0.1	< 0.1	5.5
Carbon steel	1.7	0	0	1.7
Aluminum	7.1	0	0	7.1
Copper	25	0	0	25
Storage waste	45	45	45	45
Cleanup	300	50	50	300
Total radwaste	590	~ 120	~ 120	414
Nonradioactive-waste volume (m^3):				
	980	980	980	980
Burial-land use:				
(m^2)	280	40	40	200
(ft^2)	3000	450	450	2200

†[1] Exponential notation: 1.2 E+1 = 1.2×10^1.

Table 7. Radiation Doses for Alternative Modes of Decommissioning CP-5

Radiation-Dose Category	Decommissioning Alternative #1 Dismantlement	#2 Mothball	#3 Entomb Total	#4 Entomb Bioshield Only
Nearest individual†[1] (mrem)				
Whole body	0.02	< 0.01	< 0.01	0.02
Lung	0.2	< 0.01	< 0.01	0.2
Cumulative population dose (person-rem)				
Within 80 km	8.33	0.0016	0.0016	8.33
Transportation	4.1	0.8	0.8	2.8
Cumulative occupational dose (person-rem)				
On the site	20	< 1	< 1	18
Transportation	24	5	5	17
Background dose rate†[2]				

†[1] Outdoors, at Building 301.

†[2] External radiation only (Golchert et al., "Environmental Monitoring at Argonne National Laboratory - Annual Report for 1980," ANL-81-23, 1981) 90 mrem/yr; thus, based on a population within 80 km of ANL of 7,948,000, the background population-dose rate is 715,000 person-rem/yr.

Table 8. Preliminary Exposure-Rate Estimates for Major Components of the CP-5 Reactor, Based on Measurements Made as of 1 April 1980

Reactor Component or System	Exposure Rates
Concrete biological shield	<0.1 mR/h at outer surface, 0.1-125 mR/h from outer surface to inner surface of concrete shield (via horizontal bore hole)
Lead thermal shield	20-50 mR/h at surface of core sample
Steel tank	1.0-1.5 R/h at surface of core sample, ~14 mR/h at 1 ft from core sample
Boral liner	300 mR/h at surface of core sample, ~11 mR/h at 6 in from core sample
Graphite zone	8-10 mR/h at surface of core sample
Stainless steel I beams on bottom of lower shield assembly	2000 R/h at surface
Aluminum reactor vessel	450 R/h at center of tank on centerline
Primary heat exchanger	2 mR/h at surface of side, 20 mR/h at surface of bottom

Table 9. Approximate Cumulative Occupational Doses Incurred in Decontaminating and Decommissioning CP-5†[1]

Section	Component(s)	Exposure or Mobilized Form	Time Exposed (worker-h)	Dose Equiv. Rate (mrem/h)	Cumulative Dose (person-mrem)
B.1	2 converter cylinders	Gamma	32	0.25	8
B.2	150 stainless-steel plugs	Gamma	NA†[2]	NA	15
B.3	Experimental equipment	Gamma	NA	NA	100
B.4	4 shim control rods	Gamma	NA	NA	100
B.5	1 regulating (fine-control) rod	Gamma	NA	NA	25
B.6	H-10 beam-hole assembly	Gamma	1.8	160	290
B.7	H-29 beam-hole assembly	Gamma	1.8	160	290
B.8	H-6/H-17 pneumatic-hole assembly	Gamma	1	250	250
B.9	H-2/H-21 pneumatic-hole assembly	Gamma	1	250	250
B.10	H-26 beam-hole assembly	Gamma	0.6	300	180
B.11	H-8 beam-hole assembly	Gamma	0.5	210	110
B.12	H-15 beam-hole assembly	Gamma	0.5	210	110
B.13	H-24 beam-hole assembly	Gamma	0.5	210	110
B.14	H-31 beam-hole assembly	Gamma	0.5	210	110
B.15	H-13 beam-hole assembly	Gamma	2	210	420
B.16	H-12 thermal-column assembly	Gamma	2.5	370	920
B.17	H-28 thermal-column assembly	Gamma	1.2	200	240
B.18	H-7, H-9, H-16, H-25, and H-32 instrument-port assemblies	Gamma	1.5	120	180
B.19	H-4/H-19 isotope-train assembly	Gamma, plutonium	4	610	2,400
B.20	H-3/H-22 isotope-train assembly	Gamma	5.4	580	3,100
B.21	H-1/H-20 beam-hole assembly	Gamma	3.6	290	1,000
B.22	H-5/H-18 beam-hole assembly	Gamma	4.3	280	1,200
B.23	7 large graphite-zone vertical thimbles	Dust, gamma	32	11	350
B.24	10 small graphite-zone vertical thimbles	Dust, gamma	27	15	400
B.25	11 heavy-water deuterium-zone thimbles	Dust, gamma	1.5	75	110
B.26	Top shield cover sections	-	-	-	-
B.27	Top shield inner plug assembly	-	-	-	-
B.28	Matrix of the outer top shield plug	Gamma	240	4	960
B.29	Inner top shield plug	Gamma	4	2	8
B.30	Bolts of the outer top shield plug	Gamma	8	100	800
B.31	Outer top shield plug	Gamma	8	50	400
B.32	Stainless-steel plate of the lower shield assembly plug	Gamma	8	10	80
B.33	Lifting preparations for the lower shield assembly plug	Gamma	8	50	400
B.34	Lower shield assembly plug	Gamma, tritiated water	NA	NA	110
B.35	Core tank	Dust, gamma	400	3	1,200
B.36	Annular shield	Gamma	NA	NA	2
B.37	Graphite reflector and thermal columns	Dust, gamma	NA	NA	900
B.38	Boral liner	Gamma	NA	NA	50
B.39	Steel shell	Gamma	80	1	80
B.40	Lead thermal shield	Gamma	160	1	160

Table 9. Continued

Section	Component(s)	Exposure or Mobilized Form	Time Exposed (worker-h)	Dose Equiv. Rate (mrem/h)	Cumulative Dose (person-mrem)
B.41	Biological shield	Dust, gamma	8,000	0.25	2,000
B.42	Portions of the reactor-pedestal assembly	Dust, gamma	110	3	330
B.43	Primary-system pumps	Gamma, tritiated water	20	1	20
B.44	Piping and valves	Gamma, tritiated water	50	1	50
B.45	Heat exchanger and heavy-water storage tanks				
B.45.1	Heat exchanger	Gamma	4	1	4
B.45.2	Heavy-water storage tanks	-	-	-	-
B.46	Heavy-water-purification equipment	Gamma, tritiated water	NA	NA	2
B.47	Radioactive portions of the air-exhaust and thimble-cooling systems				
B.47.1	Air-exhaust system	-	-	-	-
B.47.2	Thimble-cooling system				
B.47.2.1	Blowers	Gamma, tritiated water, plutonium	12	1	12
B.47.2.2	Piping and valves	Gamma, tritiated water, plutonium	30	1	30
B.48	Low-specific-activity scrap	Gamma	NA	NA	35
B.49	Intermediate- to high-level scrap	Gamma	NA	NA	370
B.50	Residual radioactivity	Gamma	-	-	-
B.51	Filling of holes, etc.	-	-	-	-
B.52	Conversion of facility	-	-	-	-
B.53	Demolition of structures	-	-	-	-
	Cumulative dose from all activities:				
	Workers				20,000
	Support, health-physics personnel†3				1,000
	Total				21,000

†1 Values rounded to two significant figures.

†2 Not applicable. Sufficient mitigation will be used to ensure that cumulative occupational dose will be limited to that shown.

†3 5% of cumulative dose to workers.

Table 10. Time Expended and Cumulative Occupational Dose Incurred by Three Workers in Handling and Removing Low-Level Radioactive Scrap - Building 330 Waste-Storage Yard

Item	Description	Maximum Expended Time (min/wkr)	Cum. Occ. Dose (person-mrem)
A	1 portable ion-exchange column	15	†[1]
B	7 skids of steel brick	70	2
C	7 skids of lead brick	70	†[1]
D	31 skids of concrete block	240	†[1]
E	1 rotary beam gate	20	†[1]
F	4 skids of lead ingots	40	†[1]
G	1 open-top mixing tank (3-ft dia × 4 ft)	10	†[1]
H	2 skids of polyethylene sheets	20	†[1]
I	Material from inside cave in LN_2 building	30	10
J	7 beam-port plugs (∿ 10-in dia)	30	5
K	8 port plugs (∿ 3-in dia)	10	1.5
L	7 collimators/port plugs	30	9
M	1 collimator section (cool end from cutting operation)	10	0.5
N	2 collimator sections (cool pieces from cutting operation)	20	1
O	1 beam catcher containing various materials	10	†[1]
P	1 extension tube from collimator cask	10	0.5
Q	6 large concrete slabs	360	†[1]
R	5 additional concrete slabs	300	†[1]
S	3 skids of long concrete shield blocks	180	†[1]
T	1 heat exchanger (internals contaminated)	120	2
U	1 dump tank (inside contaminated)	120	2
V	1 long tank	120	†[1]
W	1 experiment apparatus	120	1
X	1 used spent-fuel shipping cask	60	†[1]
	Total	34 h/wkr	34.5

†[1] Insignificant.

Table 11. Time Expended and Cumulative Occupational Dose Incurred by Two Workers in Handling and Removing Intermediate- to High-Level Radioactive Scrap - Building 330 Waste-Storage Yard

Item	Description	Maximum Expended Time (min/wkr)	Cum. Occ. Dose (person-mrem)
A	2 collimators (15-in dia × 9 ft)	360	15
B	1 collimator (15-in dia × ∿ 12 ft)	360	25
C	1 collimator coffin containing unidentified source	240	165
D	1 aluminum tank from west thermal column	20	165
	Total	16.5 h/wkr	370

APPENDIX A.

RADIATION SURVEYS AND MONITORING PRIOR TO DISMANTLEMENT

The estimates of occupational dose rates, used in Appendix B, are based on preliminary surveys carried out in 1980. Radiation-field measurements along the centerline of the core tank were obtained by monitoring along an empty central vertical thimble. To obtain data along a horizontal radius, a 3-inch-diameter diamond-toothed core drill was used to remove a core that penetrated through the concrete biological shield into the graphite reflector. The estimated exposure rates at contact with the principal reactor components are given in Table 8.

APPENDIX B.

PROCEDURES FOR ESTIMATING RADIOLOGICAL EXPOSURES AND NUCLIDE RELEASES FROM EACH OPERATION

The radiological impacts of each major step in the procedure for dismantlement of the CP-5 reactor is estimated by considering the technique and the time required to remove each reactor component and auxiliary facility or equipment item. A brief statement regarding each component is given in this appendix. The described techniques are those that are indicated in the preliminary "CP-5 Decommissioning and Disassembly Plan," ANL, Engineering Division, 1 June 1981. The locations and orientations of components and structures discussed in this appendix are shown in Figures 4 through 11. A tabulation of cumulative occupational doses incurred in the decontamination and decommissioning of CP-5, annotated to the sections of this appendix, is presented in Table 9.

B.1 CONVERTER CYLINDERS

Two converter cylinders, used to convert thermal (slow) neutrons to fast neutrons, presently are contained in storage tubes in the floor of the containment wing (see Fig. 5). The overall length of each cylinder is about 3 m (10 ft); however, the highly radioactive portion, made of enriched uranium and located in the center of each assembly, is less than 46 cm (18 in) long and about 10 cm (4 in) in diameter.

- Technique - CP-5 operators have experience in handling spent converter cylinders. The floor storage-tube shield plug must first be removed before a fuel-element coffin can be centered over the orifice. A worker will then lift the converter cylinder (using a cable already connected to it) up into the coffin. The coffin with its contained converter cylinder will be moved to the "cave," where the inactive ends of the cylinder can be safely severed from the highly radioactive central portion, using a mechanical cutting tool operated by remote manipulators (see Fig. 5 for cave location). The highly radioactive portions will then be moved to the fuel storage canal for underwater loading into a shipping cask located on the bottom. The loaded cask will be lifted, drained, washed off, sealed, decontaminated, and transferred to a truck for shipment, under DOT regulations, to Savannah River where the uranium content of the converters can be recovered.

- Releases - No releases are expected.

- Mitigation - The use of a shielded fuel-rod coffin, a manipulator-equipped shielded cave, and remote, underwater cask-loading operations will reduce doses to no more than those discussed below.

- Expended Time - A team of two workers will handle the converter cylinders. Based on previous experience, it is estimated that two worker-days per cylinder will be required for processing and shipping, or four worker-days for both cylinders (32 worker-hours).

- Dose - Based on past experience, it is estimated that dose rate will be about 0.25 mrem/h, for a cumulative occupational dose of 8 person-mrem to complete the task of processing the two cylinders (32 worker-hours × 0.25 mrem/h).

B.2 WEIGHT PLUGS FROM SPENT FUEL ELEMENTS

About 150 weight plugs for spent fuel elements, made from lead-filled stainless-steel pipe, are presently stored at the bottom of the fuel pool (see Fig. 5). Each one has a highly radioactive end that emits about 30 R/h (measured at about 5 cm). The inactive ends are fitted with manipulating cables.

- Technique - A worker will grasp each plug cable with a long grapple, operated manually from the top of the fuel pool. The plugs will be lifted to the top of the pool and transferred to 30-gal drums contained in a 10,000-lb drum pot already loaded onto a truck parked next to the pool. Five plugs can be loaded into each drum. The truck will transport loaded drums to the ANL reclamation facility where up to 10 loaded drums will be transferred to a DOT-approved M-3 bin for delivery to Hanford. A minimum of three such shipments will be necessary to transfer all the weight plugs. Shipments will be by truck, under DOT regulations.

- Releases - No releases are expected.

- Mitigation - Use of a long grapple, underwater transfers, other remote handling techniques, and shadow shielding will be employed to limit doses to levels discussed below. The pool area will be cleared of all personnel except for the crane operator, so that no direct exposure will occur in case of accidental drop of a plug.

- Expended Time - A single worker will be assigned to transfer the plugs to drums. Only the bottom portion of each plug is radioactive; thus, worker exposure will occur only during the period when the plug bottom is in momentary transit to a drum. It is estimated that no more than five seconds will elapse during the transfer. Because there are about 150 plugs, an actual exposure time of 750 seconds is estimated (5 seconds per plug × 150 plugs) - about 0.2 hour. However, completion of the task will take about five days.

- Dose - Operations will be designed so that the worker transferring weight plugs will receive no more than 0.1 mrem per plug, for a cumulative occupational dose of 15 person-mrem to complete the task (0.1 mrem per plug × 150 plugs × 1 worker).

B.3 EXTERNAL EXPERIMENTAL EQUIPMENT

A working definition of "external experimental equipment" used in this assessment is "any device or part of a device not permanently attached to the reactor.

This includes items such as spectrometers, diffraction apparatus, computers, cryostats, vacuum chambers and pumps, radiation counters, etc. Figure 6 shows the positioning of some of the ancillary equipment around the reactor.

Some of the external equipment contains radioactive material. Most of the equipment will be decontaminated and redistributed to other programs within ANL. The remaining unwanted low-specific-activity items will be shipped as described below.

- Technique - All low-specific-activity parts will be removed and stored in M-3 bins brought into Building 330 for the purpose of interim storage of such waste. When filled, a bin will be transferred to Hanford by truck, under DOT and NRC regulations, for disposal of its radioactive contents.

- Releases - None are expected.

- Mitigation - No specific mitigation techniques will be necessary to handle the external experimental equipment except for the exercise of good health-physics practices.

- Expended Time - Considerations of expended time are irrelevant, in that no worker will be exposed to greater-than-background radioactivity.

- Dose - It is conservatively estimated that a cumulative occupational dose of no more than 100 person-mrem will result from handling all the external equipment.

B.4 SHIM CONTROL RODS

The CP-5 reactor contains four cadmium shim control rods (see Figs. 7 and 8). They are about 1.5 m (5 ft) long. The neutron-absorbing portion of each consists of a cadmium plate between two layers of aluminum plate. Operators of the CP-5 reactor are experienced in removing and replacing these rods.

- Technique - Before a rod can be removed from the reactor, its drive shaft must first be removed from the side of the reactor. This is followed by removal of the appropriate shield plug at the reactor top, and unbolting of the rod-hanger plates. When these operations are completed, a shim-rod coffin will be centered over the open rod orifice at the top of the reactor, and a rod will be withdrawn into the coffin by means of a cable connected to the rod. The loaded coffin will then be transported to the cave where the rod will be remotely removed and mechanically cut into segments short enough to fit into a 30-gal drum. The drum will be loaded by remote manipulation with rod-blade segments until full. One or perhaps two drums will be needed to contain all the segments cut from the four rods. The drum, in a drum-pot cask, will be transported to the ANL reclamation facility by truck, for transfer to a DOT-approved M-3 bin. The loaded bin will be transported to Hanford by truck, under DOT regulations.

- Releases - No releases are expected.

- Mitigation - The use of remote techniques, a shielded cave with manipulators, and shielded casks will limit doses to the levels discussed below.

- Expended Time - It is conservatively estimated that one day will be required to remove each shim rod from the reactor, and another day for cutting and transport to the ANL reclamation facility. Four workers will be assigned the task of rod removal and processing. Thus, it will take 32 worker-days to complete the task of handling the four rods (2 workers × 2 days per rod × 4 rods) or 256 worker-hours.

- Dose - Sufficient mitigation will be used to assure that a cumulative occupational dose of no more than 100 person-mrem will be experienced to complete the task of removing and processing the four shim control rods. Of this, about 25 person-mrem will be experienced by the worker assigned to manually unbolt the rod-hanger plates to free the rods for lifting. The remaining 75 person-mrem includes all other doses incurred in processing the four rods for shipment; this includes the dose incurred in cleaning the cave.

B.5 REGULATING (FINE-CONTROL) ROD

See Figures 7 and 9 for location of the single regulating rod in the reactor.

- Technique - The CP-5 operators are experienced in removing and processing the regulating rod. Much like handling the shim control rods discussed above, the regulating rod will be disconnected from its drive, pulled up into a coffin, remotely cut in the cave to fit into a 30-gal drum, and transferred to the ANL reclamation facility for preparation and shipment to Hanford by truck, under DOT regulations.

- Releases - None are expected.

- Mitigation - Mitigation will be identical to that for the shim rods (Sec. B.4).

- Expended Time - It is estimated that 16 hours will be required to remove the regulating rod from the reactor, transfer it to the cave, and cut and process it for shipping. The total effort will be 48 worker-hours.

- Dose - Sufficient shielding will be used to assure that a cumulative occupational dose of no more than 25 person-mrem will be experienced to remove, process, and ship the regulating rod; this includes the dose incurred in cleaning the cave.

B.6 H-10 BEAM-HOLE ASSEMBLY

This hole is covered by a rotary gate.

- Technique - After preliminary procedures are completed, and the work area is prepared, a plug shielding the rotary gate will be removed and temporarily placed in an M-3 waste bin before shipping to Hanford. Next, various low-specific-activity pieces of anchoring hardware, shielding plates, and a slit mechanism will be manually removed with long-handled tools, and also placed in an M-3 waste bin. Following these procedures, a platform will be erected under the H-10 beam hole so that the orifice of a shielded coffin can be positioned against the outer face of the biological shield directly in line with the beam hole. A stainless-steel collimator, contained in the beam hole, will then be pulled into the coffin cavity by means of a wire cable. A special cutting tool inserted in a cutting port of the coffin will be used to cut through the collimator at a point about 160 cm (63 in) from its front end. The cut section will be temporarily stored in a specially shielded waste bin. Next, the collimator remnant will be pulled into the coffin, and will be placed in a 55-gal drum, which will be shielded, for temporary storage. After certain anchoring cap screws are removed, the beam-hole liner (a metal tube) will be pulled from the hole by means of a cable that will be attached to a screw hole at the end of the liner. As with the beam-hole-collimator assembly, a portion (about 75 cm or 30 in) of the liner will be pulled into a coffin and cut. The cut piece of liner will be discharged into the same shielded bin containing the cut portion of the collimator. The remnant of the liner will then be pulled from the hole and placed in the drum holding the collimator remnant. All temporarily stored radioactive materials will then be shipped by truck to Hanford, under DOT regulations.

- Releases - A small amount of radioactive scale is likely to fall from components of the beam-hole assembly as they are removed. Small amounts of low-specific-activity surface dusts may also enter the air in the vicinity of the operation. On the assumption that the 4-inch-diameter stainless-steel collimator will be sawed within the room at a cutting rate of 2.3 kg/h, the releases to the stack include 5×10^{-5} Ci of ^{60}Co, 10^{-4} Ci of ^{55}Fe, and 10^{-5} Ci of ^{63}Ni.

- Mitigation - Sufficient mitigation will be used to limit the cumulative occupational dose to that discussed below. Mitigation will include the use of shadow and other shielding, remote operation, and protective clothing and respirators. The floor of the work area will be covered by plastic film so that any scale and chips can be easily collected and disposed of. As stated in Section 4.1, a plastic-film tent enclosure with negative air pressure and HEPA-filtration capabilities will be erected and operated during dust-generating procedures. A HEPA-filter-equipped vacuum cleaner will be used to remove large quantities of dust and scale whenever necessary.

- Expended Time - It will take a team of one to four workers about three days to remove the H-10 beam-hole assembly. However, only 1.8 worker-hours will involve exposure to various levels of radiation. This exposure time is used to estimate the occupational dose given below.

- Dose - Sufficient mitigation will be used to limit the average occupational dose rate to about 160 mrem/h. At this rate, it is estimated that the cumulative occupational dose will be about 290 person-mrem.

B.7 H-29 BEAM-HOLE ASSEMBLY

Operations, and impacts resulting from this decommissioning activity, will be the same as those discussed in Section B.6.

B.8 H-6/H-17 PNEUMATIC- (RABBIT-) HOLE ASSEMBLY

A "rabbit" is a pneumatic device that can move samples rapidly to a position near the reactor core.

- Technique - After work areas adjacent to H-6/H-17 are prepared (at both the north and south faces of the biological shield), the shielding covering H-6 will be removed. Next, anchoring hardware will be removed from a section of aluminum tubing near the face of the biological shield. The tubing will be removed and its end sealed, and it will be placed for temporary storage in an M-3 waste bin positioned near H-6. A plug and stainless-steel-tubing assembly associated with H-6 will then be removed and temporarily stored in the M-3 waste bin. After anchoring cap screws are removed, a portion of the aluminum rabbit tubing will be pulled from the reactor, by means of a wire cable, into a coffin placed against the orifice of hole H-6. When about 150 cm (60 in) of tubing is contained in the coffin, a special tool placed in a cutting port will be used to mechanically sever the tubing. The coffin will then be moved to a hot cell. Here, the tubing will be cut in half. The coffin will then be repositioned at H-6 and another 150-cm section will be pulled out and cut off, and subsequently cut in the hot cell. The sections of tubing will be transferred in the hot cell to a drum that has been shielded. About 40 cm (16 in) of tubing will remain in the hole. However, this tubing is only slightly radioactive and will be put in an M-3 waste bin.

  Final operations for removal of the rabbit will be conducted at H-17 at the south face of the biological shield. After various pieces of anchoring hardware are removed, a shielding plug adjacent to the orifice will be removed; a specially constructed end shield will be attached to the highly radioactive portion of the plug, which faced the interior of the reactor. The shielded plug will be temporarily stored in a waste bin until it can be transferred to Hanford. Next, a vacuum-seal extension rod and stop-tube assembly will be pulled out of the reactor for a distance of about 61 cm (24 in) and will be mechanically cut. The cut section will not be highly radioactive, and will be placed in an M-3 waste bin. The section remaining in the reactor will be highly radioactive. It will be pulled by cable into a coffin placed against the H-17 orifice, and transferred in the coffin to a hot cell where it can be cut in half to fit inside a shielded drum. Finally, a stainless-steel vacuum-seal ring in H-17 will be shielded and placed in an M-3 waste bin. All radioactive wastes will be shipped to Hanford, under DOT regulations.

- Releases - Estimated releases are about two orders of magnitude smaller than those described in Section B.6; i.e. radioactive-particulate release will be from cutting the thin aluminum liner, and scale and dust.

- Mitigation - Mitigation will be similar to that discussed in Section B.6.

- Expended Time - It will take a team of one to four workers about four days to remove assembly H-6/H-17. However, only one worker-hour will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.

- Dose - Sufficient mitigation will be used to limit the average occupational dose rate to about 250 mrem/h. At this rate, it is estimated that the cumulative occupational dose will not exceed 250 person-mrem.

B.9 H-2/H-21 PNEUMATIC- (RABBIT-) HOLE ASSEMBLY

Operations, and impacts resulting from this decommissioning activity, will be the same as those discussed in Section B.8.

B.10 H-26 BEAM-HOLE ASSEMBLY

This assembly has a 12-inch diameter and is covered by a 12-inch rotary gate.

- Technique - A shielded cutting platform will be constructed adjacent to the H-26 gate. After the gate is fixed in the open position, a wire cable will be attached to the aluminum collimator assembly inside the beam hole. About 55 cm (22 in) of the collimator will be drawn into the shielded cutting platform, and cut. The cut section will be remotely transferred by crane to a 55-gal drum, which will be shielded. A cable will then be attached to the collimator remnant in the hole, and the remnant will be pulled and placed into another drum that has been shielded. A cable will then be attached to the liner inside H-26, and the liner will be pulled into the shielded cutting platform to a distance of about 69 cm (27 in). After the exposed liner is cut at this point, the cut section will be transferred to one of the two 55-gal drums discussed above; the remnant of the liner will then be pulled from the hole by cable and transferred to another drum. The rotary gate, which is only slightly radioactive, will be closed and left on the reactor for its shielding properties; it will be removed later, when the biological shield and its sheathing are removed. All drummed radioactive material will be shipped to Hanford by truck, under DOT regulations.

- Releases - Possible releases will be similar to those described in Section B.6. The collimator will be sawed within a plastic tent, with a conservatively estimated release of 10^{-5} Ci of ^{60}Co to the stack.

- Mitigation - Mitigation will be similar to that discussed in Section B.6.

- Expended Time - It will take a team of one to four workers about three days to remove the H-26 beam-hole assembly. However, only 0.6 worker-hour will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.

- Dose - Sufficient mitigation will be used to limit the average occupational dose rate to about 300 mrem/h. At this rate, it is estimated that the cumulative occupational dose will be about 180 person-mrem.

B.11 H-8 BEAM-HOLE ASSEMBLY

The H-8 beam hole is equipped with a vertical gate.

- Technique - A shielded coffin will be horizontally positioned adjacent to H-8. A collimator assembly (about 140 cm or 56 in long) contained in the beam hole will then be pulled into the coffin by means of a wire cable. The loaded coffin will be transported to a hot cell where the collimator will be discharged, placed in a special jig, and cut into two equal-sized pieces. The pieces will be temporarily left in the hot cell. After the empty coffin is returned to H-8, an internal adaptor will be removed from the hole and transferred for temporary storage to an M-3 waste bin. After the beam gate is raised, a wire cable will be attached to a second (graphite) collimator contained within the beam hole. The collimator will be drawn into the coffin and transported to the hot cell where it will be cut into two pieces about 61 cm (24 in) long. The pieces will be temporarily left in the hot cell. After the coffin is returned to H-8, the aluminum beam-hole liner will be freed from its moorings, and will be drawn out of the hole by means of a cable. The liner will then be cut into two pieces about 61 cm (24 in) long. All the radioactive scrap will then be placed in a single 55-gal drum, which will be shielded, for truck shipment to Hanford, under DOT regulations.

- <u>Releases</u> - Possible releases will be similar to those described in Section B.8.
- <u>Mitigation</u> - Mitigation will be similar to that discussed in Section B.6.
- <u>Expended Time</u> - It will take a team of one to four workers about three days to remove the H-8 beam-hole assembly. However, only about 30 worker-minutes will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.
- <u>Dose</u> - Sufficient mitigation will be used to limit the average occupational dose rate to about 210 mrem/h. At this rate, it is estimated that the cumulative occupational dose will not exceed 110 person-mrem.

B.12 H-15 BEAM-HOLE ASSEMBLY

Operations, and impacts resulting from this decommissioning activity, will be the same as those discussed in Section B.11.

B.13 H-24 BEAM-HOLE ASSEMBLY

Operations, and impacts resulting from this decommissioning activity, will be the same as those discussed in Section B.11.

B.14 H-31 BEAM-HOLE ASSEMBLY

Operations, and impacts resulting from this decommissioning activity, will be the same as those discussed in Section B.11.

B.15 H-13 BEAM-HOLE ASSEMBLY

The H-13 beam hole is covered by a 12-inch rotary gate.

- <u>Technique</u> - After a collar is removed from the reactor face at H-13 and transferred as low-specific-activity waste to an M-3 bin, a gate around the beam hole will be removed and similarly stored. A shielded cutting platform will be placed against the face of the biological shield adjacent to H-13, and an inner cast-steel collimator will be drawn about 71 cm (28 in) into the shield by means of a cable. The protruding portion will be severed mechanically through a cutting port in the shielded platform; the cut section will be removed from the shield and will be placed temporarily in the waste bin. The more radioactive remnant will be drawn from the reactor and transferred remotely to a 55-gal drum, which will be shielded. After anchoring hardware is removed and a cable attached, the beam-hole liner will be pulled into the shielded platform and a 69-cm (27-in) piece will be cut. This section will also be placed in the drum, as will the remnant that will be pulled from the hole. The drummed radioactive scrap and the low-specific-activity waste will be transferred by truck to Hanford.

- Releases - It is estimated that the cut through the steel collimator will release about 10^{-4} Ci of ^{60}Co and ^{55}Fe.

- Mitigation - Mitigation will include a plastic-film tent enclosure with negative air pressure and HEPA-filtration capabilities.

- Expended Time - It will take a team of one to four workers more than four days to remove the H-13 beam-hole assembly. However, only about two worker-hours will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.

- Dose - Sufficient mitigation will be used to limit the average occupational dose rate to 210 mrem/h. At this rate, it is estimated that the cumulative occupational dose will not exceed 420 person-mrem.

B.16 H-12 EAST-THERMAL-COLUMN ASSEMBLY

- Technique - After the outer collimator is removed from H-12 and placed in an M-3 waste bin, the east face plate of the reactor, encompassing H-13, will be removed. This steel face plate, which is not radioactive, is about 1.8 m (6 ft) square and will be flame cut into quarters so that the pieces may be accommodated in an M-3 waste bin; flame cutting is acceptable in this dismantling procedure because the face plate is not significantly radioactive. After various anchoring hardware and small components are removed, two layers of masonite board and two layers of lead bricks will be manually removed. The lead will be transferred on skids for reuse elsewhere at ANL. The masonite will be cut or broken into pieces small enough to fit into the waste bin. Additional layers of masonite and lead will then be removed from areas above and below the H-12 gate housing, and similarly disposed of. Next, the gate mechanism and its counterbalance will be removed. Because the apparatus is oddly shaped and quite radioactive (~ 15 R/h at 5 cm), a custom-made shielded shipping cask, approved by DOT and NRC, will receive it. Then, a steel/boral assembly, which retains the graphite, will be removed and placed in the bin; it is anticipated that the shielding provided by the bin will result in a level of surface radiation in compliance with shipping regulations. If measurements show that this is not the case, a specially shielded waste bin will be substituted. The exposed components (collimators and collimator inserts) are made of bismuth, lead, and graphite; after anchoring hardware is removed, the components will be remotely grasped, removed, and placed into an M-3 bin lined with concrete blocks for additional shielding. It will then be necessary to mechanically cut or disconnect certain piping in H-12, associated with a bismuth filter, a heavy-water tank, and associated piping. When freed, both the tank and filter will be placed in the shielded waste bin. Finally, residual shims, spacers, and other alignment hardware will be removed and put in the same bin. All radioactive materials will be shipped by truck to Hanford, under DOT regulations.

- Releases - Some radioactive dust and scale may be released, but no cutting releases will be encountered.

- Mitigation - Mitigation will be similar to that discussed in Section B.6. In addition, local ventilation, including tents, elephant trunks, and HEPA filters, will be used as necessary.

- Expended Time - It will take a team of one to four workers about eight days to dismantle the east-thermal-column assembly. However, 2.5 worker-hours will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.

- Dose - Sufficient mitigation will be used to limit the average dose rate to about 370 mrem/h. At this rate, it is estimated that the cumulative occupational dose will not exceed 920 person-mrem.

B.17 H-28 WEST-THERMAL-COLUMN ASSEMBLY

- Technique - After the nonradioactive seal-sheet retaining bars and other anchoring hardware are removed from the H-28 area, the seal sheet will be removed and placed into an M-3 waste bin. Next, plastic shielding material, an outer collimator, and a collimator-shutter mechanism will be removed and placed into the bin. The exposed structure of lead-brick shielding will then be dismantled and transferred on skids for reuse elsewhere at ANL. Additional plastic shielding will be removed to the M-3 bin. After various mechanisms are disconnected at the reactor shelf and above H-28, a double-taper collimator, graphite-housing section, bismuth filter, and upper shutter section will be removed from the reactor and placed in an M-3 waste bin positioned near H-28. An additional collimator positioned in the graphite-housing section will then be removed from the reactor to the bin. Next, a bismuth filter will be withdrawn; because of its rather low radioactivity (~ 0.5 R/h), it will be placed in an M-3 waste bin. Finally, the remaining components (certain shutter sections and the shutter housing, adapter rods, and hardware) will be removed from the reactor to the bin. The reactor shelf plate and other shielding devices will then be reattached to the reactor to provide shielding for subsequent decommissioning steps.

- Releases - Possible releases will be similar to those discussed in Section B.16.

- Mitigation - Mitigation will be similar to that discussed in Section B.6, except that a plastic-film tent enclosure with negative air pressure and HEPA-filtration capabilities will be included.

- Expended Time - It will take a team of one to four workers more than four days to remove the H-28 beam-hole assembly. However, only about 1.2 worker-hours will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.

- Dose - Sufficient mitigation will be used to limit the average occupational dose rate to about 200 mrem/h. At this rate, it is estimated that the cumulative occupational dose will not exceed 240 person-mrem.

B.18 H-7, H-9, H-16, H-25, AND H-32 INSTRUMENT-PORT ASSEMBLIES

The procedures and impacts for these five instrument-port assemblies are the same. The impacts of any one of them are given in this section.

- Technique - Three 20-cm (8-in) -diameter outer shield plugs cover the assembly. These will be removed and transferred to an M-3 waste bin. After various electronic components are disconnected and anchoring hardware removed, an inner shield plug, ion chambers, other electronics, and boral plates will be withdrawn and placed into the bin. The three outer shield plugs will then be reinstalled to provide temporary protection for workers carrying out other decommissioning activities. All radioactive-waste materials removed from the assembly will be shipped to Hanford by truck, under DOT regulations.

- Releases - Possible releases will be similar to those discussed in Section B.16.

- Mitigation - Mitigation will be similar to that discussed in Section B.6.

- Expended Time - It will take a team of one to three workers no more than 15 man-hours, five hours elapsed time, to remove the assembly. However, only about 0.3 worker-hour will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.

- Dose - Sufficient mitigation will be used to limit the average occupational dose rate to 120 mrem/h. At this rate, it is estimated that the cumulative occupational dose will not exceed 36 person-mrem.

B.19 H-4/H-19 NORTH ISOTOPE-TRAIN ASSEMBLY

- Technique - The north isotope-train facility contains six aluminum thimbles installed in an isotope-train-plug assembly. The isotope-train plug is composed of a front section of heavy concrete encased in steel with a segment of about 7.5 cm (3 in) of lead next to a rear section of graphite. Before the north isotope train can be disassembled, it will be necessary to remove the spectrometer shielding from the north and south faces of the reactor shield.

  It is proposed to remove and discard the external isotope-train plug (external to the reactor face). The six aluminum thimbles will next be removed and disposed of by being cut up in the hot cell. The isotope-train plug will then be pulled out about 2 m (6 ft) and disconnected at the juncture of the concrete/lead to graphite. The front (concrete and lead) section (about 680 kg or 1500 lb) will then be placed in an M-3 bin and disposed of. The graphite section remaining (about 3 m or 10 ft long and weighing 393 kg or 866 lb) will be drawn into a plastic bag and discarded. (If necessary, this section can be disassembled into 1.2-m- or 4-ft-long graphite stringers of 9.8 × 8.9 cm or 3-7/8 × 3-1/2 inch cross section.) The final operation will be the removal and cutting up of the aluminum inner liner.

- Special Handling for Pu Contamination - In 1972, about 30 mg of irradiated ^{239}Pu was inadvertently vaporized, and contaminated the H-4/H-19 north isotope-train horizontal thimble and its associated local-ventilation system. Much of this material appeared to have been trapped in the filter of the thimble-ventilation system, and was disposed of. However, it was not possible to conduct an accurate inventory of the recovered plutonium because the plastic polymer used to contain and isolate the sample also vaporized and admixed with the plutonium. Some of the plutonium/plastic residuals may remain in the north isotope-train assembly and in a portion of the thimble-cooling system. Because no accurate inventory is available, it is conservatively assumed that all 30 mg of plutonium is still present in the system, although in all probability only a small fraction actually remains.

  It will be necessary to take precautions against the possibility that some ^{239}Pu may still remain in the facility. A plastic tent will be constructed at the north face of the reactor, within which the disassembly will be performed. The air within the tent will be exhausted through a HEPA filter to the exhaust stack. Workers will wear self-contained breathing apparatus.

- Releases - Estimated releases from cutting the aluminum liner are 4×10^{-6} Ci of ^{60}Co. A reasonable estimate of ^{239}Pu release would be 0.1% of 30 mg in the form of airborne particulates released to the tent. Assuming one HEPA filter, the total transmission to the reactor room would be 8×10^{-10} Ci. Assuming that this is emitted over an eight-hour period, at 28×10^{6} cm^3/min of airflow, the concentration would be about 10×10^{-20} Ci/cm^3 air, or about the maximum permissible limit for unrestricted access.

- Mitigation - Careful monitoring of the air in the tent will be exercised to adjust airflow rates so that airborne ^{239}Pu concentrations are below permissible limits for unrestricted areas.

- Expended Time - It will take a team of one to four workers more than four days to remove the H-4/H-19 assembly. However, only about four worker-hours will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.

- Dose - Sufficient mitigation will be used to limit the average dose rate to 610 mrem/h. At this rate, it is estimated that the cumulative occupational dose will not exceed 2.5 person-rem. The total dose to the population from the release of ^{239}Pu is estimated to be on the order of 10^{-6} mrem for each organ in the maximum individual and about 3×10^{-3} person-rem for the 80-km radius.

B.20 H-3/H-22 SOUTH ISOTOPE-TRAIN ASSEMBLY

- Technique - After the exterior H-3 "roll-up shield" is removed and transferred to an M-3 waste bin, an ion-chamber holding plug will be moved to the side, and the two contained ion chambers will be removed for reuse elsewhere at ANL. The plug will then be removed and transferred to the waste bin. The removal of anchoring hardware and other small components will then enable the workers to withdraw the largest of four thimbles from the assembly, and put it into a plastic bag. The most highly radioactive end of the thimble will then be immediately placed into a shielded coffin positioned near the work area. The remaining three smaller thimbles will be similarly handled. The loaded coffin will be transported to a hot cell where the thimbles will be discharged and cut into sections short enough to fit into a 55-gal drum.

  The plug assembly remaining in H-3/H-22 will be withdrawn about 215 cm (7 ft) so that the hardware connecting the "concrete/lead section" to the "graphite section" can be removed, in a fashion similar to that discussed in Section B.19. Low-specific-activity portions will then be transferred to the M-3 bin; higher activity materials will be placed into 55-gal drums, which will be shielded. Graphite blocks and other materials with a high potential for creating dust will be wrapped in plastic before they are placed into containers for shipment.

  The remainder of the dismantling procedure for the south isotope-train assembly is similar to that for the north assembly, as described in Section B.19.

- Releases - An estimated 4×10^{-6} Ci of ^{60}Co will be released to the exterior from three cuts through the aluminum liner. Dust and scale releases may occur.

- Mitigation - Mitigation will be similar to that discussed in Section B.6.

- Expended Time - It will take a team of one to four workers more than four days to remove the H-3/H-22 assembly. However, only about 5.4 worker-hours will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.

- Dose - Sufficient mitigation will be used to limit the average dose rate to 580 mrem/h. At this rate, it is estimated that the cumulative occupational dose will not exceed 3.1 person-rem.

B.21 H-1/H-20 BEAM-HOLE ASSEMBLY

- Technique - After three shielding plugs are removed, a titanium transfer tape contained in the hole will first be wound onto its reel. The 580-cm

(19-ft) tape will then be gradually pulled from the reel into a shielded coffin, and cut into sections short enough to fit into an intermediate- to high-level radioactivity cask. Cutting will be done from a remote location, because it is estimated that the radiation field near the tape will be about 50 R/h. Next, the shielding and source-transfer mechanism will be removed from the south face of the reactor shield, and the detector shield from the north face; these materials will be transferred to an M-3 waste bin. After various coolant lines are disconnected, and some lead and concrete cylinder plugs and a boral cylinder are removed (all low-specific-activity waste), a special structure will be constructed at the north face. The structure will permit a shielded coffin equipped with a cutting port to be placed in such a position that the aluminum beam-tube liner, including some internals (collimator, finned cooler), can be pulled by cable directly into the coffin for cutting with a special tool. The first cut section, about 150 cm (60 in) long, will not be highly radioactive, and will be transferred to an M-3 bin. The next 150-cm portion of the assembly remaining in the hole will then be drawn by cable into the coffin, transported to the hot cell, and be cut into two sections, each about 75 cm (30 in) long. The pieces will be left in the hot cell temporarily. The coffin will be returned to the reactor face where it will receive another 150-cm-long liner residual. This too will be cut into two 75-cm sections. After various lead plugs, cap screws, a short liner section, a stop disc, and a sleeve are removed from the north end of H-1/H-20, and discarded in the M-3 bin, the remaining portion of the aluminum liner tube will be pulled and cut in stages, the final cuts being made in the hot cell as described above. All the cut sections in the hot cell will then be placed into drums, which will be shielded, for truck shipment to Hanford, under DOT regulations.

- Releases - Possible releases will be similar to those discussed in Section B.20.

- Mitigation - Mitigation will be similar to that discussed in Section B.6.

- Expended Time - It will take a team of one to four workers slightly more than seven eight-hour shifts to remove the H-1/H-20 beam-hole assembly. However, only about 3.6 worker-hours will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.

- Dose - Sufficient mitigation will be used to limit the average dose rate to about 290 mrem/h. At this rate, it is estimated that the cumulative occupational dose will not exceed 1.1 person-rem.

B.22 H-5/H-18 BEAM-HOLE ASSEMBLY

- Technique - After two shields are removed from H-5/H-18 at its north face, a source-tube mechanism will be removed. Different portions of the mechanism are characterized by substantially different levels of radioactivity; each portion will be placed in a shielded disposal structure compatible with its radiation level. A source-tube subassembly will then be partially withdrawn, some anchoring hardware removed, and an associated lead/lithium carbonate shield will be removed and placed into an

M-3 waste bin. A shielded platform will then be constructed at the north face. A 150-cm (60-in) section of the source tube will be withdrawn by cable into a shielded coffin placed on the platform adjacent to the beam hole. This section will be cut through a cutting port. The loaded coffin will be transported to a hot cell where the tube will be cut into two equal-sized sections and temporarily stored. This will be repeated for the section of the source tube remaining in the reactor at the north face.

At the south face, a collimator will be separated where its lead and bismuth portions are joined. The lead portion and the connecting hardware will be placed into an M-3 waste bin. It will be appropriately shielded for shipment. The aluminum "fixed" tube will then be pulled from the reactor by cable to a distance of about 150 cm (60 in), so that a number of anchoring bolts and a lead gasket can be removed. The tube-section connecting hardware will then be placed into an M-3 waste bin. A shielded platform will then be constructed at the south face. The tube remnant in the hole will be drawn into a coffin, cut off, and further reduced in length in the hot cell in three successive operations, similar to those described above. When this is accomplished, the aluminum liner (still in the hole) will be similarly handled. The radioactive scrap temporarily stored in the hot cell will then be placed in 55-gal drums, which will be shielded, for truck shipment to Hanford, under DOT regulations.

- Releases - Possible releases will be similar to those estimated in Section B.20.
- Mitigation - Mitigation will be similar to that discussed in Section B.6.
- Expended Time - It will take a team of one to four workers more than eight eight-hour shifts to remove the H-5/H-18 beam-hole assembly. However, only about 4.3 worker-hours will involve exposure to various levels of radiation. This exposure time is used to estimate the cumulative occupational dose given below.
- Dose - Sufficient mitigation will be used to limit the average dose rate to 280 mrem/h. At this rate, it is estimated that the cumulative occupational dose will not exceed 1.2 person-rem.

B.23 LARGE GRAPHITE-ZONE VERTICAL-THIMBLE ASSEMBLIES

The CP-5 reactor contains seven "large" graphite-zone vertical-thimble assemblies (see Figs. 7 and 8).

- Technique - Before a thimble assembly can be lifted, eight retainer cap screws and a stainless-steel wafer must be removed at the top of the reactor. Following these operations, a lifting yoke will be attached to a spacing ring beneath the thimble flange. A cable will connect the lifting yoke to the polar crane.

  Because only the bottom of each thimble assembly is highly radioactive, and because the coffin to which it will be transferred cannot accommodate its entire length, a special technique has been devised for its removal. The thimble assembly will be monitored for radioactivity as it is slowly withdrawn by the crane. When the highly radioactive portion is located, the assembly will be lowered back until this portion is eclipsed by the reactor top plug. Next, a hole will be drilled in the slightly radioactive exposed portion so that a pin can be inserted to retain the thimble in its new position. This accomplished, the exposed portion will be mechanically cut free and transferred to an M-3 bin kept in Building 330 to hold collected low-specific-activity wastes for interim storage. The crane cable will then be attached to the protruding part of the cut assembly, and the highly radioactive portion will then be lifted from its channel into a shim-rod coffin for transfer to the cave. Here, the thimble assembly will be mechanically cut, remotely, to fit into a 30-gal drum. The filled drum will be placed in an M-3 waste bin and will be shipped to Hanford in the half super tiger overpack, under DOT regulations.

- Releases - Small amounts of low-specific-activity surface contamination and scale may fall onto the top of the reactor during the removal of the thimble assemblies, but no dispersion of significant airborne concentrations is expected.

- Mitigation - Protective clothing will be worn by workers handling the thimble assemblies and, if warranted, respirators will be worn. The use of remote techniques, a shielded cave with manipulators, shielded containers, and shadow shielding will limit doses to the levels discussed below.

- Expended Time - A team of two workers will require up to one day to remove and process each thimble assembly; however, it is estimated that no more than 135 minutes of this time would involve exposure. Thus, the total time would be no more than 1890 worker-minutes (2 workers × 135 minutes per assembly × 7 assemblies) or 31.5 worker-hours.

- Dose - Taking into consideration the 31.5 worker-hours calculated above, sufficient mitigation will be used to limit the cumulative occupational dose to no more than 50 person-mrem per assembly, for a total of 350 person-mrem (50 person-mrem per assembly × 7 assemblies).

B.24 SMALL GRAPHITE-ZONE THIMBLES

There are ten "small" thimbles in the graphite zone of the CP-5 reactor (see Figs. 7 and 8).

- Technique - Before the small thimbles can be removed, it will be necessary to lift their protective center-shield plugs; the radioactive ends of the plugs will be put into shield caps as soon as they are removed from the thimble holes. They will be shipped to Hanford in this protected configuration.

  After the anchoring hardware is removed, each thimble will be pulled up into a specially constructed coffin positioned over the thimble hole on top of the reactor. The remainder of the operation will be similar to that discussed in Section B.6 (i.e. cutting each thimble into appropriately sized fragments in the "cave," and shipment to Hanford).

- Releases - The only releases expected are small quantities of radioactive surface scale; some of this material may flake off during removal of the thimbles and fall onto the reactor top, but the majority will be released in the shielded environment of the cave. No releases to the general environment are expected.

- Mitigation - Workers in the vicinity of the operation will wear protective clothing and, if warranted, personal respirators. Local ventilation, including tents, elephant trunks, and HEPA filters, will be employed if appropriate.

- Expended Time - A team of three workers (of whom two will be exposed) will accomplish the removal, processing, and transfer of the thimbles. Although these operations may conservatively take as much as one day per assembly, actual exposure time will be no more than 80 minutes per assembly. Because there are ten assemblies, total exposure time will be 1600 worker-minutes (2 workers × 80 minutes per assembly × 10 assemblies) or 26.7 worker-hours.

- Dose - Taking into consideration the 26.7 worker-hours calculated above, sufficient mitigation will be used to limit the cumulative occupational dose to 40 person-mrem per assembly, or 400 person-mrem for all ten assemblies.

B.25 HEAVY-WATER (DEUTERIUM-ZONE) THIMBLES

There are 11 thimbles in the deuterium zone of the CP-5 reactor, the volume within the aluminum core tank (see Fig. 9).

- Technique - Removal of the deuterium-zone thimbles will be similar to the removal of the small graphite-zone thimbles, discussed in the previous section. Processing and shipping operations will be similar to those for the large graphite-zone thimbles, discussed in Section B.23.

- Releases - Releases will consist of small quantities of radioactive surface scale, similar to that expected from the small graphite-zone thimbles, discussed in Section B.24.

- Mitigation - Mitigation will be similar to that used in other thimble-removal and -processing operations, as discussed in Sections B.23 and B.24.

- Expended Time - A team of two workers will remove, process, prepare the thimbles for shipping. Slightly more than one day per thimble will be required. Exposure time will not exceed 240 seconds per assembly. Total exposure time will be 5280 worker-seconds (2 workers × 240 seconds per assembly × 11 assemblies) or about 1.5 worker-hours.

- Dose - Sufficient mitigation will be used to limit the cumulative occupational dose to 10 person-mrem per assembly, or 110 person-mrem for all 11 assemblies.

B.26 TOP SHIELD COVER SECTIONS

- Technique - The top shield cover sections are not radioactive. They will be cleaned of surface dirt after the anchoring hardware is removed. They will then be lifted by the polar crane, placed on a truck parked on the reactor floor of Building 330, and transported to an ANL landfill for burial.

- Releases - None are expected.

- Mitigation - None is required.

- Expended Time - Not relevant to this impact assessment.

- Dose - None is expected.

B.27 TOP SHIELD INNER PLUG ASSEMBLY

- Technique - This plug is flush with the top shield cover (see Figs. 8 and 11). It is not inherently radioactive, but is likely to have some surface contamination that will have to be removed before burial. The cleaned plug will be removed from the reactor by the polar crane, placed on a truck parked on the reactor floor of Building 330, and transported to an ANL landfill for burial.

- Releases - None are expected.

- Mitigation - Good health-physics practices during the removal of surface contamination will be employed. After the plug is removed, a number of penetrations in the remaining lower plugs will be shielded to reduce direct radiation. The open holes will be filled with fuel-element internal plugs outfitted with solid-center shield plugs. Also, lead plates will be positioned where warranted.

- Expended Time - Not relevant to this impact assessment.

- Dose - None is expected.

B.28 MATRIX OF THE OUTER TOP SHIELD PLUG

The outer top shield plug is located slightly above the inner top shield plug assembly (see Figs. 8 and 11). It is not inherently radioactive. The volume of the plug is filled with a matrix of steel punchings in paraffin wax. With the matrix in place, the weight of the plug is greater than the capacity of the polar crane; therefore, the matrix must be removed before the plug can be lifted from the reactor.

- Technique - The paraffin-and-steel matrix will be mechanically loosened with hand-held power tools. The broken material will then be manually transferred to 55-gal drums. The filled drums will be sealed and disposed of in an ANL landfill.

- Releases - The paraffin and steel are not expected to be radioactive and no releases of hazardous materials are expected.

- Mitigation - None will be required except for the shielding described in Section B.27.

- Expended Time - It is conservatively estimated that paraffin removal will require eight worker-hours per drum. Assuming that 30 drums will be filled, the total expended time to complete the operation will not exceed 240 worker-hours (8 worker-hours per drum × 30 drums).

- Dose - The operators will plug open holes and use sufficient lead shielding to reduce the dose rate in the work area to no more than 4 mrem/h at mid-body level of a standing worker. The cumulative occupational dose for the matrix-removal operation is estimated to be 960 person-mrem (240 worker-hours × 4 mrem/h).

B.29 INNER TOP SHIELD PLUG

- Technique - The upper surface of this plug is slightly lower than the upper surface of the matrix of the outer top shield plug, and will be removed after the operation described in Section B.28 has been performed. It is not inherently radioactive, but is likely to have some surface contamination that will have to be removed before burial. The cleaned plug will be removed from the reactor by the polar crane, placed on a truck parked on the reactor floor of Building 330, and transported to an ANL landfill for burial.

- Releases - None are expected.

- Mitigation - Good health-physics practices during the removal of surface contamination will be employed. After the plug is removed, a number of penetrations in the remaining lower plug will be shielded to reduce direct radiation. The open holes will be filled with fuel-element internal plugs outfitted with solid-center shield plugs. Also, lead plates will be positioned where warranted.

- Expended Time - With a crew of two men, an elapsed time of two hours will be required.

- Dose - The dose rate will be no more than 2 mrem/h; thus, the cumulative occupational dose will not exceed 8 person-mrem (2 workers × 2 hours × 2 mrem/h).

B.30 BOLTS OF THE OUTER TOP SHIELD PLUG

- Technique - Before the outer top shield plug can be lifted, eight bolts near the periphery must be loosened. The bolt heads are eclipsed by a flange (with little top clearance) near foot level. During past operations involving the turning of the bolts, correct placement of a wrench on the bolt heads was accomplished by "feel". For the present decommissioning operation, optical aid such as a periscope will be employed to permit the worker to view the operation. A special ratchet wrench will be devised to turn the bolts; this will involve fewer wrench repositionings as compared to past operations; thus, worker-time will be decreased.

- Releases - None are expected.

- Mitigation - None will be required except for the shielding described in Section B.27.

- Expended Time - It is estimated that one worker-hour will be required to loosen each bolt. The total expended time will be eight worker-hours (1 worker-hour per bolt × 8 bolts).

- Dose - Because it will be necessary for the worker to assume a prone position during most of the bolt-loosening procedure, the average dose rate will be greater than the 4-mrem/h rate estimated for the paraffin-removing operation. The worker will also be closer to localized areas of radiation in the vicinity of the bolt heads. Taking this into account, it is conservatively estimated that the worker will experience a dose rate of 100 mrem/h. Thus, the cumulative occupational dose is estimated to be 800 person-mrem (8 worker-hours × 100 mrem/h).

B.31 OUTER TOP SHIELD PLUG

- Technique - Eyebolts will be attached to the outer top shield plug, and a cable from the polar crane will be attached to the eyebolts. Next, a flatbed truck holding an approved container will be parked on the reactor floor in Building 330. The plug will then be hoisted by the crane, operated from a remote location. Four workers will wrap the plug in plastic film while it is suspended, to contain any loose contamination (in the form of rust and scale) that could be released from the plug during its transport to Hanford. The plug will be lowered, on edge, into the container, which will then be closed, blocked, secured, and covered by tarpaulins. It will be delivered to Hanford, under DOT regulations.

- Releases - Pieces of low-specific-activity rust and scale will fall onto the reactor top when the plug is lifted. Large releases of fine particulates are not expected during the plug-lifting operation.

- Mitigation - None will be required except for the shielding described in Section B.27.

- Expended Time - It is estimated that plug lifting, wrapping, and transferring to the truck will be accomplished by a team of four workers expending less than eight worker-hours.

- Dose - The average dose rate for all operations is very conservatively estimated to be 50 mrem/h. Thus, the cumulative occupational dose is estimated to be 400 person-mrem (8 worker-hours × 50 mrem/h).

B.32 STAINLESS-STEEL PLATE OF THE LOWER SHIELD ASSEMBLY PLUG

- Technique - This plate is located below the outer top shield plug (see Fig. 11). Before the lower shield assembly plug can be lifted, it will be necessary first to cut an associated, restraining, stainless-steel seal plate, and then to remove 36 cap screws. These operations will be remotely performed by mechanical means. No flame cutting will be employed. The plate will be cut into pieces and placed into appropriate containers and shipped to an offsite radioactive-waste burial site.

- Releases - None are expected.

- Mitigation - Shielding as described in Section B.27, and the use of remote techniques, will reduce doses to the limits estimated below.

- Expended Time - It is estimated that it will require eight worker-hours for one worker to remove the stainless-steel seal plate and cap screws.

- Dose - Although the radiation field in the vicinity of the seal plate and cap screws will be on the order of 200 mR/h, the worker will be remotely positioned to experience an average dose rate of no more than 10 mrem/h. It is estimated that the cumulative occupational dose will not exceed 80 person-mrem (8 worker-hours × 10 mrem/h).

B.33 LIFTING PREPARATIONS FOR THE LOWER SHIELD ASSEMBLY PLUG

- Technique - Additional tasks must be completed before the lower shield assembly plug can be lifted; these include the removal of clamping at the periphery of the plug, disconnection of certain plug-cooling tubes, attachment of eyebolts to the top of the plug, and attachment of the polar-crane cables to the eyebolts. All such tasks will be accomplished manually, using conventional tools.

- Releases - None are expected.

- Mitigation - Sufficient distance and local shielding will be used to limit doses to those given below.

- Expended Time - The above tasks will require eight worker-hours for completion. Two workers will share the jobs, each working four hours.

- Dose - Dose rate will vary, depending on the position of a worker, from a maximum of 200 mrem/h at the face of the upper surface of the plug to 20 mrem/h beyond the periphery. Assuming an average dose rate of 50 mrem/h, it is conservatively estimated that a cumulative occupational dose of 400 person-mrem (8 worker-hours × 50 mrem/h) will be incurred in completing the tasks.

B.34 LOWER SHIELD ASSEMBLY PLUG

This plug is very radioactive on its underside (side facing the core cavity); preliminary measurements indicate a radiation field of about 2000 R/h at the I beams, which are integral parts of the plug. This is attenuated to about 200 mR/h at the top of the plug. A custom-built cask will be located on a flatbed trailer parked alongside the reactor prior to lifting the plug. The cask will have a cavity at its upper surface, sized to receive the plug, underside down.

The core tank will have been emptied for more than two years when the lower shield assembly plug is lifted, and will be dry (it is probably dry at the present time); however, for conservatism it is assumed that when the plug is lifted from the core tank there will be a gaseous release of tritium contained in a heavy-water atmosphere, saturating the core-tank volume (7.22 m^3 or 255 ft^3). Assuming that, at saturation, 1 m^3 contains about 20 grams of heavy water, one entire atmosphere of the core tank would contain about 0.5 Ci of tritium (the tritium content in the CP-5 heavy water is about 3 Ci/L). Thus, the assumed release of tritium is 0.5 Ci. The tritium-contaminated atmosphere will be removed from the vicinity of the core tank by local ventilation, including tents, elephant trunks, and HEPA filters as necessary, to remove about 30 m^3/min (1000 ft^3/min) of air from the vicinity of the top of the core tank. It is assumed that all traces of tritium would be vented outside the containment in one hour and diluted in about 1700 m^3 (60,000 ft^3) of air (i.e. about 300 μCi/m^3 or 8400 μCi/min).

- Technique - The plug will be lifted by the polar crane, controlled by an operator from a remote location. It will be lifted to slightly above the level of the top of the cask (which will be on the flatbed truck parked adjacent to the reactor), be manually guided into position over the cask cavity by a worker with a long pole, and then be lowered into the cavity. After the cask cover is secured, the truck will deliver the cask to Hanford, under DOT regulations.

- Releases - It is assumed that 1% of a 10-nm (100-angstrom) oxidation film on the underside of the stainless-steel I beams becomes airborne during removal of the plug and that 2.5 × 10^{-3} Ci of ^{60}Co, 4 × 10^{-3} Ci of ^{55}Fe, and 4 × 10^{-3} Ci of ^{63}Ni are released to the stack.

- Mitigation - The workers will be stationed at such distances and with sufficient shadow shielding to result in radiation doses no greater than those discussed below. The worker guiding the plug over the cask cavity will be closest (about 3 m or 10 ft) to the highly radioactive portion of the plug.

- Expended Time - The remotely stationed crane operator will require about 30 minutes to lift the plug, await its manual positioning, lower the plug into the cavity of the cask, and position the cask cover. It is conservatively assumed that the pole-equipped worker will require no more than six minutes to position the plug over the cask cavity, prior to its lowering.

- Dose - The crane operator will conduct the plug-lifting operation from such a location, and with such shielding, that his dose rate will be no greater than 20 mrem/h. The cumulative dose for this operator will be 10 person-mrem (0.5 worker-hour × 20 mrem/h). The pole handler will receive a substantially greater dose, even at the end of the 3-m (10-ft) pole. It is estimated that, even with shadow shielding, the pole handler will experience a dose rate of about 1 rem/h. Assuming a maximum exposure time of six minutes or 0.1 hour, this person will receive a cumulative dose of 100 person-mrem (0.1 worker-hour × 1 rem/h). Thus, the cumulative occupational dose to the crane operator and pole handler is 110 person-mrem.

The assumed gaseous tritium release occurring when the plug is lifted, described above, will result in a cumulative population dose to persons on the ANL site of about 80 person-mrem.

B.35 CORE TANK

- Technique - The core tank is constructed of 3/8-inch reinforced 2S-1100 aluminum (see Figs. 8 and 9). It will be mechanically cut, probably with an abrasive wheel, while immersed in the fuel-storage pool in the annex to Building 330. The cut pieces will fit into a cask positioned underwater. Remotely operated tools will be used for the cutting operation. The work will be observed from a remote location by using optical devices.

  The primary hazard in the operation will be the removal of the 1.8-m (6-ft) diameter and 2.9-m (9-ft 7-in) -high cylindrical tank from the reactor to a specially designed transport cart on rails that will be placed in the reactor room. The self-propelled cart will carry the tank from the reactor room through a hallway and into the annex, where the fuel-storage pool is located. Inasmuch as preliminary radiation monitors have indicated an activity in the aluminum of over 500 R/h, the lifting of the unshielded tank from its pedestal to above the reactor and lowering it to rest on the transport cart will create the major occupational dose and presents the possibilities of measurable airborne-nuclide release.

- Releases - Of the several possible ways of cutting up the core tank, the selected technique outlined above poses the least release from the cutting operation, because cutting will be carried out underwater by a remotely operated saw. However, there will be several parts of the operation that will have to be carefully planned so as to minimize occupational exposure due to direct contact with the tank during preparations for lifting and to direct exposure to radioactive "shine" from the interior of the tank. In addition, there will be exposure to possible airborne and falling particulates of aluminum-oxide scale on the exterior of the tank. These activated particulates will present an inhalation and skin-contact exposure to workers within the building and to the public in the path of the building exhaust. On the conservative assumption that a 10-nm (100-angstrom) oxide film, containing the same relative composition per unit weight of nuclides given in Table 4, has formed on the tank exterior, and 10% of this film becomes airborne during the tank lifting and transport, the airborne release is calculated to be 10^{-2} Ci of ^{60}Co, 10^{-4} Ci of ^{55}Fe, and 5×10^{-5} Ci of ^{182}Ta.

- Mitigation - Appropriate use of remote procedures during transport and cutting and shadow shielding of workers will minimize doses. In addition, if monitoring of radiation during the initial lifting stage indicates greater activity than assumed beforehand, the core tank will be returned to its pedestal and mitigating procedures will be reconsidered so as to ensure that workers receive adequate shielding.

- Expended Time - Considering the experience gained in removing the core tank during decommissioning of the Ames Laboratory Research Reactor ("Decommissioning and Decontamination Activity - Ames Laboratory Research

Reactor, Iowa State University," USDOE, DOE/EA-0026, 1978), it is estimated that dismantling of the CP-5 core tank will take about 200 worker-days (1600 worker-hours). However, only 25% of this will involve exposure (the remainder being set-up time, logistics, etc.). Thus, 50 worker-days (400 worker-hours) are assumed to involve exposure to radiation; only one worker at a time will be permitted to work in the radiation field.

- Dose - Sufficient mitigation will be used to assure that the cumulative occupational dose will not exceed 600 person-mrem. The maximum-individual public dose from this operation alone will be 0.04 mrem from inhalation at Building 301 on the ANL site.

B.36 ANNULAR SHIELD

The annular-shield assembly lies immediately above the graphite zone of the reactor (see Fig. 8).

- Technique - The assembly is constructed of concrete, with a 7.5-cm (3-in) -thick lead plate at the bottom. The concrete may have to be mechanically broken and the lead mechanically cut from remote locations. The assembly has a low-specific-activity classification, and will be transferred to a flatbed truck for delivery to Hanford, under DOT regulations.

- Releases - None of consequence are expected.

- Mitigation - Remote handling and shadow shielding will be used to limit doses to those discussed below.

- Expended Time - No more than three days each will be required of two workers to remove and transfer the annular-shield assembly to the flatbed truck, for a total of six worker-days (2 workers × 3 days) or 48 worker-hours.

- Dose - Sufficient protection will be employed to limit each worker's dose to 1 mrem. The cumulative occupational dose will be 2 person-mrem (2 workers × 1 mrem).

B.37 GRAPHITE REFLECTOR AND THERMAL COLUMNS

The graphite reflector and thermal columns are located below the annular shield (see Fig. 8).

- Technique - The graphite structures are constructed of fitted blocks. The blocks will be grasped by machine from a remote location, and will be transferred to casks located nearby. Casks will be delivered to Hanford, under DOT regulations.

- Releases - Some small quantity of graphite dust will become airborne during handling of the fitted blocks. The dust will contain a correspondingly small fraction of the nuclides given in Table 4. With the very conservative assumption that a 0.25-cm (0.1-in) layer of graphite is removed from each block, and that all of this becomes airborne dust, the nuclide release is 0.003 of the total nuclide content. Assuming that 5×10^{-4} of this release is not trapped by the HEPA filters used in conjunction with the plastic tents, the total releases of ^{55}Fe and ^{14}C are 2.5×10^{-5} Ci and 4×10^{-6} Ci, respectively.

- Mitigation - Protective clothing will be worn by workers, as will respirators if warranted. Local ventilation, including tents, elephant trunks, and HEPA filters, will be used as necessary to collect the graphite dust. These measures, plus remote handling and the use of shielding, will limit exposure of workers and public to potentially hazardous material and radiation.

- Expended Time - A team of three workers will require 50 days of elapsed time to dismantle the graphite reflector and the two thermal columns of CP-5.

- Dose - Sufficient mitigation will be provided to limit the cumulative occupational dose to 900 person-mrem.

B.38 BORAL LINER

The boral liner is a cladding attached to the CP-5 steel shell (see Fig. 9).

- Technique - The boral liner consists of sintered boron-carbide grains sandwiched in 1/4-inch aluminum sheeting. Using remote techniques, the boral will be sprung free of its anchors. The exact method of reducing the cladding to pieces sized to fit a transportation cask has not yet been determined, but because of the extreme hardness of boron carbide, and its resistance to cutting, a combination of scoring of the aluminum surface and then bending of the cladding is planned. These operations (including cask filling) will be carried out inside the reactor shield, but from remote locations.

- Releases - On the assumption that a 10-nm (100-angstrom) aluminum-oxide film becomes airborne during cutting and folding of the liner, the following releases to a tent are estimated: 5.1×10^{-3} Ci of ^{60}Co, 8×10^{-5} Ci of ^{55}Fe, and 1.5×10^{-3} Ci of ^{113}Cd. A HEPA filter would reduce the release to the exterior to 10^{-7} Ci, maximum.

- Mitigation - If a large amount of surface contamination is found on the cladding, local ventilation will be used to remove and trap airborne particulates. All operations will be carried out from remote locations. Mitigation will be employed to whatever extent necessary to limit doses to the levels discussed below.

- Expended Time - Two workers will be employed for two weeks to remove and pack the boral cladding. However, a presently unidentifiable portion of that time will involve exposure to radiation.

- Dose - Dose will be limited to 25 mrem for the entire task, for a cumulative occupational dose of 50 person-mrem (25 mrem × 2 workers).

B.39 STEEL SHELL

The shell is fabricated from 1/2-inch mild steel (see Fig. 9).

- Technique - Because of the hazards inherent in vaporizing radioactive materials, flame cutting (a practical technique for cutting steel plate) will not be used for dismantling. Mechanical abrasion cutoff wheels will be employed, controlled from remote locations, to cut the steel into square pieces, 76 cm (2.5 ft) on a side, to fit a cask positioned on the reactor floor. Lead thermal shielding is in direct contact with the steel, and any lead incidentally removed with the steel tank sections will be placed in the casks with the steel for disposal at Hanford.

- Releases - With the methodology described in Section 4.1, the following airborne radionuclide releases are estimated: 2.8×10^{-2} Ci of ^{60}Co, 3.6×10^{-2} Ci of ^{55}Fe, and 3.6×10^{-4} Ci of ^{63}Ni. These estimates make up the largest single source among all the dismantlement operations.

- Mitigation - Although the releases are relatively large among the operations to be performed, they are still relatively small with regard to background doses to the public. With the expected large volume of cutoff-wheel dust, it would be advisable to consider the use of two or more HEPA filters in a series within the ventilation-control tent.

- Expended Time - Ten worker-days (80 worker-hours) will be required for two workers to cut the shell, load casks with the cut sections, and prepare the casks for shipment.

- Dose - Occupational dose rate will be limited to 8 mrem/d (1 mrem/h). Thus, the cumulative occupational dose will be 80 person-mrem (10 worker-days × 8 mrem/d). The maximum individual dose to a person not involved with the decommissioning would be a lung contamination of 0.12 mrem, associated primarily with the ^{60}Co release.

B.40 LEAD THERMAL SHIELD

- Technique - The lead thermal shield with its embedded copper cooling tubing is located between the structural steel shell and the concrete biological shield (see Fig. 9). Remotely operated heavy machinery will be used to push the lead blocks away from the concrete shield, toward the reactor center. Tools will then be used to remotely cut the lead tacking that holds the blocks together at their corners, and to sever the copper cooling tubing, where necessary. No flame cutting or melting techniques will be used. The copper is expected to be much more radioactive than the lead, so it will be remotely segregated and loaded into a cask located on the reactor floor. The lead will be loaded into M-3 bins, also on the reactor floor; but, because of the weight of lead and the limited weight capacity of the bins, the lead will probably be mixed with lighter low-specific-activity material to take full advantage of the volume capacity of the bins. The cask and bins will be prepared for transfer by truck to Hanford, under DOT regulations.

- Releases - No releases of consequence are expected because heat will not be used for disassembly.

- Mitigation - Sufficient distance, remote handling, and use of shielding will be employed to limit doses to those discussed below. Local ventilation of the work area, including tents, elephant trunks, and HEPA filters, will be used as necessary.

- Expended Time - It is estimated that it will take four workers five days to disassemble and ship the lead thermal shield (20 worker-days or 160 worker-hours).

- Dose - Occupational dose rate will be limited to 8 mrem/d (1 mrem/h), for a cumulative occupational dose of about 160 person-mrem to complete the task (20 worker-days × 8 mrem/d).

B.41 BIOLOGICAL SHIELD

Except for a sheathing of 1/2-inch steel plate, the 140-cm (56-in) -thick concrete biological shield is the outermost part of the reactor (see Fig. 9).

- Technique - In the present discussion, it is assumed that the concrete shield will be removed from the outside surface toward the inside. However, even though radioactivity of some portions of the inner surface may be as high as 125 mR/h, recent measurements of core samples taken from the shield indicate that the radiation field through most of the concrete averages only about 10 mR/h. Thus, an option exists to remove the shield from the inside.

  The steel sheathing will be cut from the face of the biological shield and will be hauled away for disposal in an ANL landfill. The concrete is of a special formula, in which the conventional gravel or crushed-stone component is replaced by limonite, a hydrous ferric oxide. The limonite gives strength to the concrete but, in addition, increases its density and hence its shielding properties. Additional shielding is provided by steel punchings densely interspersed throughout the concrete. The matrix is about 2-1/2 times as dense as conventional concrete.

  Power tools will be employed to break the concrete mechanically. Further size reduction to chunks appropriately sized for disposal will be accomplished with sledge hammers. The nonradioactive rubble will be loaded into trucks and disposed of in an ANL landfill. The low-specific-activity rubble will be loaded into trucks, covered, and shipped to Hanford, under DOT regulations.

- Releases - Concrete dust will be released during the disassembly of the biological shield. Particles mobilized from most of the shield will be insignificantly radioactive, but could pose a health hazard if inhaled in large quantities. Particles from the innermost part of the shield will be more radioactive than those from other parts.

- Mitigation - Local ventilation, including tents, elephant trunks, and HEPA filters, as necessary, will remove most airborne particles from the vicinity of the workers. Filters will prevent the particles from being exhausted to the air outside the CP-5 containment. Workers will be required to wear respirators during any operations that can result in the release of large quantities of dust.

- Expended Time - It is estimated that about 1000 worker-days (8000 worker-hours) will be required to remove the biological shield (20 workers × 50 days).

- Dose - It is conservatively estimated that no worker will receive, on the average, more than 2 mrem/d (about 0.25 mrem/h). Thus, the cumulative occupational dose for the entire task of removing the shield will be about 2 person-rem (1000 worker-days × 2 mrem/d).

B.42 PORTIONS OF THE REACTOR-PEDESTAL ASSEMBLY

Portions of the reactor-pedestal assembly are radioactive. The level of activity of these portions is likely to be similar to the average of that of the inside of the concrete biological shield - about 10 mR/h; however, the activity adjacent to some pipe penetrations in the pedestal may be higher. Also, the steel billets, which rest on I-beams, are embedded in the concrete and will have high radioactivity (see Fig. 8).

- Technique - Manual means will be used to remove radioactive portions of the concrete pedestal. As with the biological shield, large pieces will be separated from the pedestal with power hammers. Further size reduction will be accomplished with sledge hammers. The low-specific-activity pieces will be hand-loaded into M-3 bins for truck delivery to Hanford, and the radioactive steel billets will also be sent to Hanford, under DOT regulations. Nonradioactive portions will not be removed.

- Releases - Concrete dust, some containing particles of low specific activity, will be released during the operation.

- Mitigation - As with the removal of the biological shield, use of local ventilation, protective clothing, and respirators will protect the workers from both radioactive and nonradioactive dust particles. If necessary, work will be performed remotely because of high induced radioactivity in the billets.

- Expended Time - It is estimated that it will take no more than two weeks for a team of two workers to complete the task. However, of this time, only about 70% will involve exposure. Thus, the worker-time spent in the radiation field will be 112 worker-hours or less (2 workers × 80 hours × 70%).

- Dose - The average dose rate experienced by the workers will be about 3 mrem/h. Therefore, the cumulative occupational dose will be about 336 person-mrem (112 worker-hours × 3 mrem/h).

B.43 PRIMARY-SYSTEM PUMPS

- Technique - The CP-5 reactor has three large and two small primary-system pumps in the basement of Building 330 (see Fig. 7). They will be disconnected from their associated piping and all orifices will be sealed immediately with flange covers. The pumps will be lifted by crane to the main floor of the building for transfer to a truck for delivery to the ANL reclamation facility. Here, any surface contamination will be removed prior to shipping by truck to Hanford, under DOT regulations.

- Releases - Small amounts of tritium will be released from open orifices until they are sealed with flange covers. Small amounts of contaminated surface dusts may also be released.

- Mitigation - Local ventilation, including tents, elephant trunks, and HEPA filters, will be provided as necessary. Due to small amounts of surface contamination on some of the pumps, protective clothing will be worn by the workers who handle them. To minimize the release of tritium, as much as possible of the residual heavy water in the disconnected joints will be collected in vessels and sealed. In addition, respiratory protection will be employed to reduce the worker-dose commitment from released tritium oxide.

- Expended Time - It will take a team of two workers no more than two hours to prepare each pump for removal and transfer to the ANL reclamation facility. Inasmuch as five pumps will be removed, total expended time will be 20 worker-hours (2 workers × 2 hours per pump × 5 pumps).

- Dose - The dose rate in the vicinity of the pumps is estimated not to exceed 1 mrem/h. Therefore, the cumulative occupational dose incurred in removing the pumps will be 20 person-mrem or less (20 worker-hours × 1 mrem/h).

  On the highly unlikely assumption that all contaminated heavy water in the system is allowed to evaporate and release all contained tritium, it is conservatively estimated that 12 Ci of tritium will escape to the environment through the Building 330 air-exhaust stack as a result of removing the primary-system pumps and the piping and valves (piping and valves are discussed in the following section). This could result in a cumulative population dose of less than 2×10^{-3} person-rem to persons within 80 km (50 mi) of Building 330. The maximum-individual dose would be about 5×10^{-3} mrem to the whole body or any body organ.

B.44 PIPING AND VALVES

Pipes and valves of the primary system are in the basement of Building 330 (see Fig. 7). Orifices exposed during disconnection from other components will already have been sealed with flange covers.

- Technique - The remaining valves and pipe sections will be disconnected, and the exposed orifices immediately sealed with flange covers. The various components will then be disconnected from their anchors, lifted by crane to the main floor, and placed on a truck for transfer to the ANL reclamation facility. Here, the surfaces of the components will be cleaned prior to truck transfer to Hanford, under DOT regulations.

- Releases - Small amounts of tritium vapor will be released from open orifices when the seals between the piping and valves are broken. These releases will stop when the orifices are sealed with flange covers. Some contaminated surface dusts may also be released when the pipes and valves are handled.

- Mitigation - Protective clothing will be worn by workers, and respirators will be used if warranted. Local ventilation, including tents, elephant trunks, and HEPA filters, will be used as necessary until all the orifices are sealed. If contaminated dust is released during the operations, local ventilation will be continued. To minimize tritium release, any contaminated heavy water leaking from unflanged joints will be collected in vessels and sealed.

- Expended Time - A team of two workers will devote an estimated maximum of 25 hours of radiation exposure to disconnecting, sealing, and removing the primary-system piping and valves (about 50 connections). Thus, the total exposure time will be no more than 50 worker-hours (2 workers × 25 hours).

- Dose - It is estimated that the average dose rate at the open orifices will not exceed 1 mrem/h. Thus, the cumulative occupational dose will amount to 50 person-mrem or less (50 worker-hours × 1 mrem/h).

  Cumulative population dose due to this operation is discussed in Section B.43.

B.45 HEAT EXCHANGER AND HEAVY-WATER STORAGE TANKS

B.45.1 Heat Exchanger

- Technique - The heat exchanger, a cylindrical component about 3 m (10 ft) long and 1 m (3 ft) in diameter, will be removed as a unit by lifting it with the polar crane through an overhead hatch (see Fig. 7). Prior to lifting, all open orifices will be sealed with flange covers. The heat exchanger will be secured to a flatbed truck parked on the main floor of the reactor building. The truck will convey the component to Hanford, under DOT regulations.

- Releases - The external surface of the heat exchanger is not radioactive, and there will be no releases from this source.

- Mitigation - Local ventilation, including tents, elephant trunks, and HEPA filters, will be used as necessary during the isolation of the heat exchanger. No other mitigative measures will be necessary.

- Expended Time - Although it could take up to a day for two workers to remove the heat exchanger and secure it to a truck for delivery to Hanford, it will take them no more than two hours to isolate the device from the environment, the only period during which exposure will occur. Thus, the total exposure time will be no more than four worker-hours (2 workers × 2 hours).

- Dose - Dose rate in the vicinity of open heat-exchanger orifices is estimated to be no more than 1 mrem/h. Therefore, the cumulative occupational dose will not exceed 4 person-mrem (4 worker-hours × 1 mrem/h).

B.45.2 Heavy-Water Storage Tanks

- Technique - The heavy-water storage tanks will be removed by lifting them with the polar crane through an overhead hatch (see Fig. 7). Prior to lifting, all open orifices will be sealed with flange covers. The tanks will be secured to a flatbed truck parked on the main floor of the reactor building. The truck will convey the components to Hanford, under DOT regulations.

- Releases - The external surfaces of the storage tanks are not radioactive, and there will be very minimal releases of tritium from this source.

- Mitigation - Local ventilation, including tents, elephant trunks, and HEPA filters, will be used as necessary during the isolation of the heavy-water storage tanks. No other mitigative measures will be necessary.

- Expended Time - It could take up to four days for two workers to remove the heavy-water storage tanks and secure them to a truck for delivery to Hanford. However, the exposure time will be only a few minutes.

- Dose - The dose rate is expected to be minimal because the workers will be exposed for only a few minutes to very low levels of radioactivity from tritium.

B.46 HEAVY-WATER-PURIFICATION EQUIPMENT

The heavy-water-purification equipment consists of two resin beds and four filters, contained in modular units. This equipment is adjacent to the heat exchanger.

- Technique - Removal and transfer of the modules has been a routine operating procedure. After the connecting pipes are isolated by closing their valves, they will be disconnected and capped; the modules will then be rolled on their own casters to the Building 330 elevator for lifting to the main floor, wheeled to a waiting truck, and sent to ANL reclamation services for removal of the resins and filter cartridges. The filter elements and ion-exchange-bed resins will be removed. The empty modules will then be wheeled to a waiting truck for transfer to Hanford, under DOT regulations. The resins and filters will be temporarily stored as low-specific-activity waste, but will ultimately be shipped to Hanford.

- Releases - A small amount of heavy water containing tritium will escape when the pipe connections are separated. Also, some tritium releases are expected at the ANL reclamation facility when the filter cartridges and ion-exchange resins are removed. The majority of the heavy water will be collected and saved for eventual disposal. A small amount will evaporate and be exhausted from Building 330 to the ANL environment.

- Mitigation - Protective clothing will be worn. Local ventilation, including tents, elephant trunks, and HEPA filters as necessary, will be used in the vicinity of the operations until all sealing procedures are completed and residual tritium-contaminated heavy water has been collected in vessels and sealed. Wherever appropriate, respiratory protection will be used.

- Expended Time - A team of two workers will remove the resin beds. It takes a maximum of 30 minutes to process each of the two beds; thus, it will take a total of two worker-hours to complete the task (2 workers × 1/2 hour per bed × 2 beds). It will then take the team a maximum of

30 minutes to properly handle each of the four filters, for a total of four worker-hours (2 workers × 1/2 hour per filter × 4 filters). The total expended time for the complete operation of removing the two resin beds and four filters will be six worker-hours (2 + 4 worker-hours).

- Dose - On the basis of measurements taken during the routine changing of resin beds and filters, it is estimated that the complete task will involve a cumulative occupational dose of no more than 2 person-mrem.

  On the highly unlikely assumption that all contaminated heavy water in the system is allowed to evaporate and release all contained tritium, it is conservatively estimated that 2 Ci of tritium will escape to the environment through the Building 330 air-exhaust stack as a result of removing the heavy-water-purification equipment. This could result in a cumulative population dose of about 3×10^{-4} person-mrem to persons within an 80-km radius.

B.47 RADIOACTIVE PORTIONS OF THE AIR-EXHAUST AND THIMBLE-COOLING SYSTEMS

B.47.1 Air-Exhaust System

After the CP-5 reactor is dismantled, and the main radioactive components are removed from Building 330, the task of dismantling the building-exhaust system will begin.

- Technique - It is planned to dismantle the exhaust system from the reactor side toward the exhaust side. This approach will meet two objectives: it will (1) result in the removal of the most contaminated portions first and (2) allow operation of the remaining portion until any remaining dust-generating procedures have been completed.

  In the following description, dismantling of the exhaust system is discussed as a continuum, even though there will be planned, sequenced delays in completing the entire task. The building exhaust channels consist of conventional metal ductwork as well as air passages through concrete structures. The ductwork will be dismantled by routine disassembly procedures and by manual cutting. The surfaces of the concrete portions of the ductwork will be decontaminated if necessary. The blower will be removed last. All contaminated materials (i.e. those having low-specific-activity contamination on inside surfaces) will be shipped by truck, under DOT regulations, to Hanford for proper disposal. Nonradioactive components will be buried in an ANL landfill.

- Releases - No releases of radioactive material to the environment are expected.

- Mitigation - No need for special mitigative procedures is identified.

- Expended Time - Several weeks will be required for the dismantling of the exhaust system, but none of this time will involve exposure to radiation.

- Dose - No dose is anticipated.

B.47.2 Thimble-Cooling System

B.47.2.1 Blowers

- Technique - The thimble-cooling-system blowers are located in the basement of Building 330. They will be disconnected from their associated piping and all orifices will be sealed immediately with flange covers. The blowers will be lifted by crane to the main floor of the building for transfer to a truck for delivery to the ANL reclamation facility. Here, any surface contamination will be removed prior to shipping by truck to Hanford, under DOT regulations. If necessary, the components will be disposed of as transuranic waste.

- Releases - Small amounts of contaminated surface dusts may be released.

- Mitigation - Due to small amounts of surface contamination on some of the blowers, protective clothing will be worn by the workers who handle them. Local ventilation, including tents, elephant trunks, and HEPA filters, will be used as necessary.

- Expended Time - It will take a team of two workers no more than two hours to prepare each blower for removal and transfer to the ANL reclamation facility. Inasmuch as three blowers will be removed, total expended time will be 12 worker-hours (2 workers × 2 hours per blower × 3 blowers).

- Dose - The dose rate in the vicinity of the blowers is estimated not to exceed 1 mrem/h. Therefore, the cumulative occupational dose incurred in removing the blowers will be 12 person-mrem or less (12 worker-hours × 1 mrem/h).

B.47.2.2 Piping and Valves

Pipes and valves of the thimble-cooling system are in the basement of Building 330 (see Fig. 7). Orifices exposed during disconnection from other components will already have been sealed with flange covers.

- Technique - The remaining valves and pipe sections will be disconnected, and the exposed orifices immediately sealed with flange covers. The various components will then be disconnected from their anchors, lifted by crane to the main floor, and placed on a truck for transfer to the ANL reclamation facility. Here, the surfaces of the components will be cleaned prior to truck transfer to Hanford, under DOT regulations. Some plutonium may be found in the piping and valves. The components will be disposed of as transuranic waste, if necessary.

- Releases - Some contaminated surface dusts may be released when the pipes and valves are handled.

- Mitigation - Protective clothing will be worn by workers, and respirators will be used if warranted. Local ventilation, including tents, elephant trunks, and HEPA filters, will be used as necessary until all orifices are sealed. If contaminated dust is released during the operations, local ventilation will be continued.

- Expended Time - A team of two workers will devote an estimated maximum of 15 hours of radiation exposure to disconnecting, sealing, and removing the thimble-cooling-system piping and valves. Thus, the total exposure time will be no more than 30 worker-hours (2 workers × 15 hours).

- Dose - It is estimated that the average dose rate at the open orifices will not exceed 1 mrem/h. Thus, the cumulative occupational dose will amount to 30 person-mrem or less (30 worker-hours × 1 mrem/h).

B.48 LOW-SPECIFIC-ACTIVITY SCRAP FROM THE WASTE-STORAGE YARD

The waste-storage yard contains nonradioactive and radioactive materials accumulated during the lifetime of the CP-5 reactor.

The nonradioactive materials will either be distributed for reuse at other ANL locations or buried at an ANL landfill, and are not further discussed in this assessment.

Surveys of the radioactive materials indicate that most of the waste is of low specific activity. Table 10 identifies the types and quantities of low-specific-activity scrap. Any contaminated soil found in the waste-storage yard will be considered as waste and handled accordingly.

- Technique - Low-level wastes will be prepared for shipment in two ways: Items A through P in Table 10 will be loaded directly into M-3 waste bins; Items Q through X will first be isolated from the environment by wrapping with plastic film. All materials will then be shipped to Hanford, under DOT regulations.

- Releases - Because of extensive use of plastic-film wrapping, no releases of consequence are anticipated during removal of the low-level wastes.

- Mitigation - The use of plastic-film wrapping, and careful monitoring of topsoil that will be freshly exposed to the wind after removal of stored equipment, are mitigating practices that will be followed.

- Expended Time - Table 10 lists the maximum time estimated for a team of three workers to complete the various scrap-removal tasks. The total time expended will be about 102 worker-hours (3 workers × 34 hours). It should be noted that this is total time for the workers to complete all tasks, not the time they will be exposed.

- Dose - The last column of Table 10 lists the maximum cumulative occupational dose incurred in completing each task, and is based on radiation surveys of each of the listed materials. The cumulative occupational dose incurred in handling and removing all the low-specific-activity scrap will not exceed 35 person-mrem.

B.49 INTERMEDIATE- TO HIGH-LEVEL SCRAP

- Technique - Items A through C in Table 11 consist of large assemblies, each with one slightly radioactive and one highly radioactive end. The basic approach for processing these three items will be to disassemble or mechanically cut and remove the highly radioactive portions for disposal as intermediate- or high-level waste. They will be transferred to appropriate casks for truck shipment to Hanford, under DOT regulations. The remaining portions will be disposed of as part of the low-level scrap discussed in Section B.48.

The sealed aluminum thermal-column tank (Item D) will not be disassembled, but will be remotely lifted into a specially constructed cask for truck shipment to Hanford, under DOT regulations.

- Releases - Mechanical cutting of the collimators will produce some airborne particulates containing ^{60}Co and ^{55}Fe. Calculations of the total activity and the expected activity that will not be trapped by HEPA filters will be carried out prior to cutting.

- Mitigation - Sufficient shadow shielding, remote-handling, and tent ventilation trapping techniques will be used to ensure that the dose will not exceed that discussed below.

- Expended Time - Table 11 lists the maximum time it will take a team of two workers to complete the various tasks. The time expended for all tasks will not exceed 33 worker-hours (2 workers × 16.5 hours). It should be noted that this is total time for the workers to complete all tasks, not the time exposed.

- Dose - The last column of Table 11 lists the maximum cumulative occupational dose that will be allowed in completing each task, and is based on radiation surveys of the listed materials. The cumulative occupational dose incurred in completing all tasks will not exceed 370 person-mrem. The maximum-individual dose to the public will most probably not exceed 0.2 mrem.

B.50 RESIDUAL REACTOR-RELATED RADIOACTIVITY

Following the decontamination and/or removal and transfer of various components from the CP-5 reactor, Building 330, associated structures, and the waste-storage yard, a quantity of low-specific-activity sump water, other contaminated light water, waste tanks, processing tanks, casks, rags, paper, sweepings, and other radioactive residuals will remain. Large uncertainties in predicting the degree of decontamination that will be required for various steps of the CP-5 decommissioning prevent making realistic estimates of inventories of waste materials that will be generated. Accurate inventories will be made as reactor decommissioning proceeds.

- Technique - The various low-specific-activity materials will be classified and collected in appropriate containers (e.g. liquids will be drummed; paper, sweepings, and rags will be put into bins). The collected materials will be moved by truck to the ANL reclamation facility for preparation and final packaging for shipment. Trucks will be used to transport the packaged waste to Hanford, under DOT regulations.

- Releases - Liquids with tritium as the only contaminant will be diluted to less than 3×10^{-3} µCi/cm^3 before releasing to storm-sewer effluent.

Tritiated liquids, in general, will not be treated by evaporation-solidification techniques.

- Mitigation - Mitigative measures to be used when handling residual-waste materials have been considered and included in the major decommissioning steps discussed in this section.

- Expended Time - The time that will be needed to handle the residual-waste materials has been included in the expended time for the various decommissioning steps discussed in this section.

- Dose - Doses from handling the residual-waste materials have been included in the cumulative occupational doses estimated for the various decommissioning steps discussed in this section.

B.51 FILLING OF PENETRATIONS, HOLES, AND OTHER AREAS

After all radioactivity has been removed from the reactor pedestal and other parts of the CP-5 facility, all penetrations, holes, and gaps in the remaining concrete structures will be filled with concrete according to standard construction practice, so that the facility may be put to other uses.

B.52 CONVERSION OF THE DECOMMISSIONED FACILITY TO OTHER USES

It is anticipated that the decommissioned facility will be put to unrestricted use as office and laboratory space; however, final plans will not be available until decommissioning is well underway. As a minimum, it will be necessary that a new ventilation system be installed to replace the contaminated system removed during the decommissioning. When remodeling plans become available, the decommissioned facility will be refurbished to accommodate the planned new uses for Building 330.

B.53 DEMOLITION OF CP-5 ASSOCIATED STRUCTURES

CP-5 associated structures to be demolished include the vapor sphere, two cooling towers, J and K wings of Building 330, containment scrubber facility, liquid-nitrogen storage shed, valve- and pump-pits facility, and 25- and 50-m time-of-flight stations (see Fig. 4 for their locations).

- Technique - All structures will be demolished using standard demolition techniques, with proper precautions to avoid dispersal of asbestos fibers that may be present in insulating materials. Handling and disposal of material containing asbestos fibers will be in accordance with OSHA and EPA requirements.

- Releases - Only negligible surface contamination is present in some portions of some structures. No releases of consequence are anticipated.

- Mitigation - None will be necessary.

- Expended Time - Not relevant for the present assessment.

- Dose - None of consequence is expected.

[illegible] liquids, in general, will not be [illegible] solidification techniques.

- Mitigation - [illegible] measures to be used [illegible] have been considered and included [illegible] those [illegible] in this section.

- [illegible] - The time [illegible] will be [illegible] included [illegible] in this [illegible].

- [illegible] this section.

[illegible] WASTE VOLUME, [illegible], AND [illegible]

[illegible]

[illegible]

[illegible] that a new ventilation [illegible] removed during the [illegible] the decommissioned facilities [illegible] uses for Building 330.

8.53 DEMOLITION OF CP-5 [illegible]

CP-5 associated structures [illegible] cooling towers, J and [illegible] liquid-nitrogen storage [illegible] time-of-flight stations [illegible]

- Technique - All [illegible] techniques, with proper [illegible] that may be present [illegible] material containing [illegible] EPA requirements.

- Releases - Only [illegible] tions of some [illegible]

- Mitigation - None [illegible]

- Expended Time - The [illegible]

- Dose - None of [illegible]

X